RECLAMATION

Managing Water in the West

San Luis Drainage Feature Re-evaluation

Feasibility Report

Appendix G

Technical Review of Field and Laboratory Permeability Testing

U.S. Department of the Interior
Bureau of Reclamation
Mid-Pacific Region
Sacramento, California

November 2007

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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November 2007

86-68320
PRJ-13.00

MEMORANDUM

To: Geotechnical Engineering Group
Attention: 86-68312 (Davis)

From: Jeffrey A. Farrar
Civil Engineer, Engineering Geology Group

Subject: Technical Review of Field and Laboratory Permeability Testing – San Luis Evaporation Ponds – San Luis Drain Mitigations – Central Valley Project, California

Testing Performed by: Jared Vauk & Greg Mongano, MP-200, Tony Shanahan, 86-68320, Roger Burnett, 86-68570

INTRODUCTION

The purpose of this memorandum is to provide a review of field permeability (Hydraulic Conductivty, K) testing performed for investigation and design of evaporation ponds in the vicinity of the San Luis Drain. This review should identify any problems or errors with the field testing along with evaluation of the test procedures and validity of the measured permeability values. An extensive laboratory permeability testing program was also undertaken *[1, 2, 3]. This review will also comment on the comparison between field and laboratory values and the appropriate use of these values for design.

TESTING PROCEDURES

Reclamation Auger and Piezometer Testing

Reclamation auger hole and piezometer tests were performed in accordance with procedures in the Drainage Manual [4]. The tests were performed by Ground Water and Drainage personnel (D8570). A significant amount of piezometer and auger tests were performed for the investigations for the re-use areas. The tests were performed in general accordance with ASTM slug testing procedures [5, 6]. In slug testing, either a slug or weight is dropped into the water column to elevate the water level in the well bore, or a slug of water is removed (bailed) to reduce the water level. The water level or equilibrium pressure is monitored with time as the

* Numbers in brackets refer to entries in the bibliography

aquifer recovers. For the re-use areas and for evaporation pond areas, the slug was removed and wells allowed to recover. The auger test uses and open hole without casing, but the Piezometer test, seals a 2.5-inch riser pipe inside of hollow-stem augers above the test interval.

The Auger Tests use derivations of K according to Maasland and Haskew considering a possible barrier at the base of the test interval. Since these are shallow tests intended for drainage studies, an un-confined aquifer is used. In the Reclamation's piezometer test, K is derived using equations developed by Kirkham also assuming an un-confined aquifer. For the ASTM standards K derivations are made by methods proposed by Bouwer and Rice for un-confined aquifers, and the Hvorslev method for confined aquifers. I assume that Reclamation methods are fairly equivalent to and/or are modifications of Bouwer and Rice method. All of Reclamations tests were over-damped. Oscillatory response of the aquifer as sometimes is found in very high permeability deposits was not observed.

Most of the tests performed by Reclamations Technical Service Center (TSC) Groundwater and Drainage Staff (86-68570) were piezometer tests and great care was taken in the conduct of the test. After the riser pipe was set into the soil, a 0.5 ft test zone was hand augered below the riser. The test interval was 2.375 inch diameter. The test zone was then brushed to re-expose soil structure in fine grained soils. If required, the test interval was backfilled with sand to prevent caving. Water level was monitored with a pressure transducer data logger. Soil logs were carefully kept.

<u>Pneumatic Slug Testing</u>

In an effort to reduce testing time and effort, a new pneumatic slug test developed by Geoprobe Systems for double tube direct push equipment was used. The double tube direct push equipment is capable of taking continuous soil samples in the inner tube. The double tube system is driven with a hydraulic breaker hammer mounted to the mast of Reclamations CME 45 drill. A schematic of the test system is shown on Figure 1. After the depth to the top of the test zone has been reached, a thin walled sampler was advanced ahead of the double tube to clear the test zone. The test zone was then brushed and/or surged in an effort to develop the well. Brushing the interval was done only when the soil interval was a CH, CL, or CLs layer, i.e. soils that would not cave. If the soil sample interval was a s(ML) or SM caving conditions did not allow the interval to be brushed. Field personnel typically surged every interval before running any slug tests. Sandy zones were surged two to three times and clayey intervals were surged once or twice depending on the rate of recovery. A one-inch diameter riser pipe and slotted screen (0.01-inch slots) was set into the outer casing (shoe) of the outer tube and sealed with double
O-rings.

The pneumatic slug is produced from a pressure source and manifold on the top of the riser. A spike of pneumatic pressure is injected and the water level in the riser is depressed. A 10 psi full scale output transducer is located in the riser to monitor the pressure versus time.

Geoprobe has developed a detailed Standard Operating Procedure [7] and the procedure was recently passed as an ASTM standard [8]. We found the test to be a little easier to do than the Reclamation piezometer test. We did have some difficulties with plastic fittings and leakage. The leakage problems were easily detected. The PVC fittings sometimes leaked and the seal around the transducer cable also leaked occasionally. PVC fittings tended to wear more rapidly than comparable steel fittings. Replacement fittings must be available onsite in order to avoid delays and down time.

The slug test analysis software Slug Test Analysis (STA) Version 1.0 originally did not have the Bower and Rice equations for an un-confined aquifer, and Reclamation worked with Geoprobe Systems to modify that software. The analysis software has a correction for small diameter well friction losses in high K formations. For each field test we ran three slug trials to check repeatability. For each slug test you set a baseline pressure and fit a slope to a log normalized head versus time curve.

Laboratory Flexible Membrane Permeability

Seventy three laboratory flexible membrane permeability tests were performed in accordance with the procedure outlined in ASTM D 5084 “Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.” In this test the specimen is hand trimmed into a flexible rubber membrane. The ends of the specimens were roughened to expose soil structure. Porous stone endplates are then placed on the specimen ends. The specimen is placed in a chamber and an effective confining pressure of approximately 10 lb/in2 (psi) was applied with simultaneous increase in backpressure of the specimen. The backpressure is maintained in the specimen to drive any air bubbles into solution. Saturation is checked by B value test, and testing is performed when a B value of greater than 95 percent is reached. K testing is performed by falling head – rising tail water test. Numerous trials are made to assure K is stable. Both horizontal and vertical K was measured from the large 5.25 in diameter hollow-stem auger soil cores. The soil cores were taken in accordance with ASTM D 6151 [12]. The vertical permeability specimens were 4-inch diameter by 4-inches tall. The horizontal permeability specimens were 4-inches in diameter by 3-inches tall.

LOCATIONS OF TESTING

Reclamations Mid-Pacific Regional Office Geology Branch (MP-200) has prepared detailed boring logs and performed a bulk of the field testing for the evaporation ponds. Samples for laboratory index properties were selected by field personnel based on guidelines and directions from Robert Davis, TSC geotechnical engineer, 86-68312. The locations of the explorations, drilling logs, and slug test data, and location maps will be reported at a later date by MP Region geology staff. The locations of the testing are not be included in this memo. The MP Region

staff performed most of the pneumatic slug testing and reduced the data in the STA 1.0 software. Technical Service Center Groundwater and Drainage staff performed the bulk of the piezometer testing. Spreadsheets of piezometer test data were provided by Roger Burnett.

DISCUSSION

Pnuematic Slug Test Data

Pneumatic slug test data are summarized on Tables 1, 2 and 3 for evaporation pond sites A, B, and C respectively. Site A is the large Northern Grasslands evaporation pond site. Sites B and C are the North and Central Westlands evaporation pond sites, which are much smaller in size. Along with the test data, the soil type from either visual or laboratory test are given. The Unified Soil Classification System was used to classify the soil [10, 11]. A wide variety of soils types were tested. Testing was often performed near the top of the ground water table. This caused problems in some areas near the ground water interface as some intervals were dry or did not recover.

The results are given for several trials and for the case of confined or un-confined aquifer. Generally, the trials were within an order of magnitude and showed good repeatability. Examples of the output from the data reduction software STA version 1.0 are shown in the Appendix. Examples for a range of permeabilites, from 10^{-3} to 10^{-5} cm/sec are shown. The output is from my runs with example MP Region data files. The curve fitting and input data all appear correct. The assumption of “confined” or “unconfined aquifer” only results in a 5 to 15 percent change in K. Use of an “Unconfined Aquifer” is more appropriate for these shallow tests. You will note that the examples in the Appendix do not agree with those on the summary table. On my output runs, I used “Fully Penetrating” screen in my analysis. Analyses performed by MP region used the assumption of “Partial Penetration.” Changing from partial to fully penetrating results in an increase in K of 20 percent. Full penetration is where the aquifer layer is completely screened. Use of “Partial Penetration” is appropriate for our analyses.

For the soil types tested, the trend of the K data can be summarized by soil type as follows;

Silty Sand (SM) 10^{-3} cm/sec
Silts (ML) to Lean Clays (CL) 10^{-4} cm/sec
Lean to Fat Clays (CL to CH) 10^{-5} cm/sec.

The complete set of data for all soil types appears to be about and order of magnitude higher than anticipated. There were only few trials were the permeability of clays could be as low as 10^{-6} cm/sec. For Fat Clay (CH) we normally expect K of 10^{-6} to 10^{-7} cm/sec. The higher K was encountered in piezometer tests investigations for the re-use area. Burnett reported that the high K values in clay are likely caused by soil structure. Some of the clays have a “Blocky” or “Fissured” structure as show on Figure 2. This fissuring is likely remnant desiccation cracking.

Reclamation Piezometer Data

Over 100 auger and piezometer tests were performed in investigations for the re-use areas.

These data have not been documented in a technical memorandum. Roger Burnett from 86-68570 performed a comparison study in the Grasslands area between the pneumatic slug test and the Reclamation piezometer test. Side-by-side comparison tests were performed. The comparison data are shown on Table 4. The data also show extra information in the test zone in case layers are continuous. The soil classifications are based on the U S Department of Agriculture textural system.

Of the eight comparisons, six tests fall within the same exponential order of magnitude. Many of the tests are very close to one another. The agreement is surprising considering the difficulty running these tests. The only short coming of this comparison is the lack of data on light to heavy clays. Most of the comparison tests were in Silty Clays and Silty Clay Loams.

<u>Laboratory Flexible Membrane Permeability Testing</u>

Laboratory tests were performed on specimens trimmed from large diameter soil cores taken by the Hollow-Stem Auger (HAS) method [12]. These large diameter cores are some of the best available for geotechnical and geohydrological testing practice. The samples are highly suited for engineering properties testing including permeability tests. The cores are taken inside Acrylic liners which are inside the split barrel inside the augers. A rod type HAS system was used to prevent rotation of the inner barrel during the sampling process. The cutting shoe clearance ratio and lead distance must be adjusted for optimum sample quality. Good samples fit snugly in the liners and do not show evidence of tearing and spinning. Inspection of the tubes showed no signs of sampling disturbance and the soil samples were very high quality.

Upon receipt to the TSC Earth Sciences Laboratory, most of the sand and silty sand sections of the tubes had settled during transport. This settlement is expected with sands as it’s impossible to avoid some vibrations during shipment. The sand had settled in the tubes that were stored horizontally. The settled zones had free water on top of the sand. Fine grained soil cores were all in very good condition. The first group of samples taken in 2004 had to be stored for up to one year prior to testing. The samples were sealed and stored in a 60 percent relative humidity room. If there was any damage due to the drying it would be by drying (possible shrinkage cracking), mold, or oxidation. Drying disturbance would tend to increase permeability. Mold growth and oxidation would tend to decrease permeability. The worst effects of mold growth and oxidation are removed by the trimming, i.e., the worst effects are on the outside annulus of the sample. From observations while trimming specimens it doesn’t seem that there were any of these detrimental effects.

Laboratory test results are summarized on Tables 5 and 6. The soil type was determined from trimmings located “nearby” the test specimens, but not necessarily trimmings for each specimen trimmed. The shaded tests show horizontal and vertical test orientations for evaluation of anisotropy. Figure 3 shows a distribution of anisotropy ratio by area, and Figure 4 shows distribution of K_H and K_V by sample. There appears to be no consistent trend in anisotropy. In some areas there are higher horizontal conductivities. Considering the blocky structure of the clay (possibly from desiccation cracking) we would not expect and strong anisotropy because desiccation cracks run both horizontally and vertically perpendicular to level ground. For soils subject to desiccation cracking, the permeability will vary vertically.

Laboratory tests were performed with saline water taken from ground water taken in the vicinity of the San Luis Drain. Field tests were performed with tap water. It has been postulated that the salinity of the pore fluid has major effect on K, but it was estimated that K with tap water would be lower due to leaching of salts (especially stabilizing divalent cations) and resulting swelling of clays. However, the effect of tap water versus saline ground water was not systematically determined. A final series of three tests were performed using the treatment plant “source” water [3]. This water was high in salt content. The use of the source water lowered the permeability in two cases and increased permeability in the third specimen so the results of using source water are inconclusive.

Review of the lab data indicate that K values are two and sometimes three orders of magnitude lower that the field test data. Comparisons of the lab versus field data are shown on Table 7 and on Figure 5. On Figure 5 the range of results from the field tests are displayed by drill hole location. It is not unusual to see lab data one or two orders of magnitude lower than field tests, because of macroscopic structure effects such as secondary permeability through fissures. Even though the ends of the specimens were roughened, the application of confining pressure closes the fissures.

The laboratory data can reflect primary permeability and the possible properties of the soils when they are remolded. The lab data show that the clay and silty clay soils can be easily re-compacted to reach permeabilities of less than 10^{-7} cm/sec.

There is further bias in the laboratory data. The tube samples of cleaner sands were disturbed during transport. It was not possible to test the sand zones, therefore the laboratory data are further biased to fine grained soils.

Possible Other Tests

Large scale aquifer tests provide even a better measure of aquifer properties. The large scale tests consist of pumping from a central well and monitoring draw down is surrounding wells.

The hydraulic properties of the vadose zone have not been characterized. Infiltrometer tests may shed light on the vadose zone K. It is anticipated that the vadose zone soils should have similar or higher conductivities of the saturated soils due to desiccation cracking.

CONCLUSIONS

A review was made of the field and laboratory hydraulic conductivity testing performed for investigations of potential evaporation basins near the San Luis Drain in the Central Valley of California. Two field tests were used, the Reclamation piezometer test in conventional borings and the new pneumatic slug using direct push double tube system. Laboratory testing was performed on high quality large diameter soil samples using the flexible membrane test method with falling head, rising tail water. Field data are up to two to three orders of magnitude higher than the laboratory data. The purpose of this memorandum is to evaluate the reliability of these results. The following conclusions can be made;

1.) The field data best represent the in-situ hydraulic conductivity (K) to be used for design and modeling of fluid flow from the evaporation basins. Typical K versus soil type are as follows;

Silty Sand (SM) 10^{-3} cm/sec
Silts to Lean Clays (ML to CL) 10^{-4} cm/sec
Lean to Fat Clays CL to CH 10^{-5} cm/sec.

Permeability tests from locations nearby specific basin locations should be reviewed and individual results from specific locations can be used for design and modeling of the basins.

2.) The pneumatic slug test data appears to be reliable and compared well with Reclamation piezometer tests. Both tests were conducted using accepted consensus standards practice. For both tests, appropriate measures were taken to assure collection of high quality conductivity data.

3.) The laboratory data K values are lower than the field data by two to three orders of magnitude. It is commonly known that laboratory data are typically lower than field data. Normally the lab data run only one to two orders of magnitude lower that field data. The postulated reason for the higher field K is due to secondary structure, such as fissures in the clayey and silty soils. This macroscopic permeability in the finer soils cannot be measured effectively in the laboratory.

4.) Another reason the laboratory conductivities are so low is the fact that the sand and silty sand samples were disturbed in transport and not tested. Therefore the average lab data set appears even lower when compared to the field data.

5.) Laboratory data were collected to evaluate the anisotropy in hydraulic conductivity (K_V/K_h). In some areas there appear to be higher horizontal conductivity, while in others a difference is not apparent. If desiccation cracking is the chief structure governing K, we would expect much anisotropy, because the cracks proprogate both vertically and horizontally.

6.) Laboratory data indicate the clayey and silty soils can be easily re-compacted to achieve low conductivity.

cc: 86-68180 (Strauss), 86-68230 (Irvine), 86-68312 (Torres), 86-68320 (Farrar, Cain), 86-68570 (Burnett), MP-200 (Mongano, Sturm, Vauk)

WBR:JFarrar:kw:04/13/06/303-445-2333

c:kwasik:SanLuisKjaf

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[6] ASTM D 5912 "Standard Test Method for (Analytical Procedure) Determining Hydraulic Conductivity of an Unconfined Aquifer by Over-damped Well Response to Instantaneous Change in Head (Slug)," Volume 04.09, Construction, Soil and Rock, American Society for Testing and Materials, West Conshohocken, Pennsylvania.

[7] "Geoprobe Pneumatic Slug Test Kit," Standard Operating Procedure, Technical Bulletin No. 19344, Geoprobe Systems, Salina, Kansas, February 2002.

[8] ASTM D 7242-06 "Standard Practice for Performing Pneumatic Slug (Instantaneous Change in Head) Tests to Determine the Hydraulic Properties of Aquifers with Direct Push Ground Water Samplers," Volume 04.09, Construction, Soil and Rock, American Society for Testing and Materials, West Conshohocken, Pennsylvania.

[9]   ASTM D 5084 “Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter,” Volume 04.08, Construction, Soil & Rock, American Society for Testing and Materials, West Conshohocken, Pennsylvania.

[10] ASTM D 2487 “Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System),” Volume 04.08, Construction, Soil & Rock, American Society for Testing and Materials, West Conshohocken, Pennsylvania.

[11] ASTM D 2488 “Standard Practice for description and Classification of Soils (Visual Manual Procedure),” Volume 04.08, Construction, Soil & Rock, American Society for Testing an Materials, West Conshohocken, Pennsylvania.

[12] ASTM D 6151 “Standard Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling,” Volume 04.09, Construction, Soil & Rock, American Society for Testing an Materials, West Conshohocken, Pennsylvania.

Table 1 - Summary of Pneumatic Slug Test Results – Evaporation Pond Site B

HOLE	Soil Type	Depth (ft.)	Water Level (ft.)	Unconfined Ave. K (cm/s)	Unconfined K (cm/s) Test 1	Test 2	Test 3	Confined Ave. K (cm/s)	Confined K (cm/s) Test 1	Test 2	Test 3	Comments
ESS-05-25	(CL)s	9.0-10.0	7.1	**6.299E-04**	6.550E-04	6.124E-04	6.223E-04	**7.887E-04**	8.202E-04	7.668E-04	7.792E-04	
ESS-05-25	s(CL)	12.0-13.0	7.1	**5.772E-03**	5.219E-03	5.710E-03	6.387E-03	**6.496E-03**	5.873E-03	6.426E-03	7.188E-03	
ESS-05-25	CL	18.0-19.0	7.1	**7.869E-03**	7.809E-03	7.929E-03	NA	**8.494E-03**	8.429E-03	8.558E-03	NA	0.1 sCL layer
ESS-05-26	CL	8.3-9.3	4.5	**3.266E-04**	3.266E-04	3.266E-04	NA	**1.005E-04**	9.388E-05	1.071E-04	NA	fully penetrating
ESS-05-26	CH	12.0-13.0	4.5	**NO DATA**	no water recovery in 3 hours			**NO DATA**				no water in 3 hrs
ESS-05-27	CH	11.0-12.0	7.3	**6.334E-05**	6.470E-05	6.198E-05	NA	**8.321E-05**	8.515E-05	8.127E-05	NA	
ESS-05-27	s(CL)	14.4-15.4	7.6	**3.537E-03**	3.695E-03	3.370E-03	3.545E-03	**4.352E-03**	4.547E-03	4.147E-03	4.362E-03	
ESS-05-27	s(ML)	17.0-18.0	7.6	**6.506E-04**	6.082E-04	6.718E-04	6.718E-04	**7.462E-04**	7.187E-04	7.939E-04	7.259E-04	
ESS-05-28	CL	10.0-11.0	4.2	**5.149E-04**	3.106E-04	7.192E-04	NA	**6.385E-04**	3.851E-04	8.918E-04	NA	
ESS-05-28	s(CL)	13.5-14.5	4.2	**1.819E-04**	1.710E-04	1.927E-04	NA	**1.664E-04**	1.088E-04	2.240E-04	NA	
ESS-05-28	s(ML)	15.6-16.6	4.2	**1.156E-03**	1.186E-03	1.203E-03	1.079E-03	**1.289E-03**	1.323E-03	1.342E-03	1.203E-03	
ESS-05-29	(CL)s	5.1-6.1	3.6	**8.577E-04**	7.477E-04	9.222E-04	9.031E-04	**5.947E-04**	5.184E-04	6.394E-04	6.262E-04	fully penetrating
ESS-05-29	s(ML)	8.5-9.5	3.6	**3.298E-04**	3.182E-04	3.414E-04	NA	**3.459E-04**	3.337E-04	3.581E-04	NA	
ESS-05-29	CL	13.5-14.5	3.6	**2.380E-04**	3.235E-04	1.277E-04	2.627E-04	**2.801E-04**	3.808E-04	1.503E-04	3.091E-04	
ESS-05-30	CL	11.0-12.0	5.5	**2.385E-03**	2.367E-03	2.403E-03	NA	**2.877E-03**	2.855E-03	2.898E-03	NA	
ESS-05-30	(ML)s	18.0-19.0	5.6	**1.508E-02**	1.499E-02	1.539E-02	1.485E-02	**1.430E-02**	1.460E-02	1.422E-02	1.409E-02	

HOLE	Soil Type	Depth (ft.)	Water Level (ft.)	Unconfined Ave. K (cm/s)	Unconfined K (cm/s) Test 1	Test 2	Test 3	Confined Ave. K (cm/s)	Confined K (cm/s) Test 1	Test 2	Test 3	Comments
ESS-05-31	(CL)s	12.0-13.0	5.0	**7.571E-03**	7.452E-03	7.706E-03	7.556E-03	**9.092E-03**	8.897E-03	9.279E-03	9.099E-03	
ESS-05-31	(CL)s	14.0-15.0	5.0	**4.660E-03**	4.390E-03	5.136E-03	4.453E-03	**5.399E-03**	5.086E-03	5.951E-03	5.159E-03	
ESS-05-31	(CL)s	17.0-18.0	5.0	**2.059E-03**	2.341E-03	2.368E-03	1.468E-03	**2.203E-03**	2.504E-03	2.534E-03	1.571E-03	
ESS-05-32	(CL)s	8.0-9.0	4.7	**3.351E-05**	4.907E-05	2.685E-05	2.461E-05	**4.378E-05**	6.412E-05	3.508E-05	3.215E-05	
ESS-05-32	(ML)s	11.0-12.0	4.7	**6.116E-04**	1.662E-04	1.795E-04	1.489E-03	**1.991E-04**	2.007E-04	2.168E-04	1.798E-04	
ESS-05-33	s(ML)	10.0-11.0	8.9	**2.033E-04**	2.087E-04	1.978E-04	NA	**2.854E-04**	2.777E-04	2.930E-04	NA	0.7 s(ML) layer, near the top of water table
ESS-05-33	CL	11.0-12.0	9.1	**2.501E-04**	2.150E-04	3.295E-04	2.058E-04	**3.302E-04**	2.838E-04	4.350E-04	2.717E-04	
ESS-05-33	(ML)s	13.2-14.2	9.1	**5.665E-04**	5.417E-04	5.547E-04	6.030E-04	**6.249E-04**	5.976E-04	6.119E-04	6.652E-04	
ESS-05-33	CH	15.0-16.0	8.9	**4.502E-05**	4.802E-05	4.202E-05	NA	**5.538E-05**	5.907E-05	5.168E-05	NA	

Table 2 Summary of Pneumatic Slug Tests - Evaporation Pond Site A

HOLE	Soil Type	Depth (ft.)	Water Level (ft.)	Unconfined Ave. K (cm/s)	Unconfined K (cm/s) Test 1	Test 2	Test 3	Confined Ave. K (cm/s)	Confined K (cm/s) Test 1	Test 2	Test 3	Comments
ESS-05-01	SM	7.1-8.1	3.2	**3.094E-04**	1.303E-04	4.035E-04	3.945E-04	**3.432E-04**	1.446E-04	4.475E-04	4.376E-04	

Table 3 Summary Of Pnuematic Slug Tests - Evaporation Ponds Site C

HOLE	Soil Type	Depth (ft.)	Water Level (ft.)	Unconfined Ave. K (cm/s)	Unconfined K (cm/s) Test 1	Test 2	Test 3	Confined Ave. K (cm/s)	Confined K (cm/s) Test 1	Test 2	Test 3	Comments
ESS-05-04	s(ML)	10.0-11.0	8.5	**4.351E-04**	4.880E-04	3.479E-04	4.693E-04	**5.539E-04**	6.213E-04	4.430E-04	5.975E-04	
ESS-05-04	CL	17.0-18.0	8.5	**1.617E-04**	1.588E-04	1.646E-04	NA	**1.844E-04**	1.810E-04	1.877E-04	NA	
ESS-05-05	(CL)s	8.8-9.8	5.8	**1.314E-04**	1.513E-04	1.336E-04	1.093E-04	**1.656E-04**	1.906E-04	1.684E-04	1.377E-04	
ESS-05-06	(CL)s	13.6-14.6	10.1	**4.679E-04**	6.391E-04	2.967E-04	NA	**1.652E-04**	2.256E-04	1.048E-04	NA	
ESS-05-06	SM	17.5-18.5	10.1	**1.876E-04**	1.729E-04	2.022E-04	NA	**2.127E-04**	1.960E-04	2.293E-04	NA	

Table 4 - Comparison of Pnuematic and Reclamation Piezometer Tests

Pnuematic Slug Tests					USBR Piezometer Test			
Hole Number	USDA Soil Texture	Top Interval ft	Bottom Interval ft	Hydraulic Conductivity cm/sec	USDA Soil Texture	Top Interval ft	Bottom Interval ft	Hydraulic Conductivity cm/sec
RSS05-1a	VFSL	10.8	11.8	8.5E-04	SiC	9.5	10	2.0E-03
RSS05-1b	FSL	13.8	14.8	2.9E-04				
RSS05-1C	FSL	13.8	14.8	9.1E-04				
RSS05-3-1a	VFSL	8.3	9.3	6.0E-03	VFSL	8.5	9.1	7.5E-03
RSS05-3b	SiC	15	16	3.1E-04	SiC	15.5	16	1.3E-04
RSS05-4b	L	9	10	NoTest	L	9	9.5	5.5E-04
RSS05-7a&b	LS	12	13	1.5E-03	SiC	7	7.5	1.2E-03
RSS05-7d	VFSL	24	25					
RSS05-8b	FSL	11.7	12.7	5.0E-03				
RSS05-8b1	L	14	15	3.6E-04	L	14	14.6	6.6E-03
RSS09c	SiC	10.5	11.5		SiC	11	11.5	4.3E-04
ESS02D&H	Clay	11.1	12.1	1.1E-03				
ESS02b&c	SiCL	10	11	3.7E-04	SiCL	10	10.5	6.1E-04
ESS05-3	SiCL	7.9	8.9	2.0E-03	SiCL	8	8.5	3.0E-03

Table 5 Laboratory Flexible Membrane Test Results - #1 -2005

Drill Hole	Sample Depth	Specimen Depth	Soil Type	Low K value	High K Value	Average K Value	Number of tests performed	Direction of flow
	ft	ft		cm/sec	cm/sec	cm/sec		
EDC-03-15	2.8-5.7	5.1-5.7	CL	2.15E-07	2.36E-07	2.27E-07	6	Vertical
EDC-03-15	8.6-11.5	9.1-9.6	CL	1.18E-05	1.48E-05	1.31E-05	7	Vertical
EDC-03-16	6.5-9.4	7.1-7.5	ML	4.09E-06	7.33E-06	**6.39E-06**	6	**Horizontal**
EDC-03-16	6.5-9.4	7.5-7.9	ML	1.73E-07	1.91E-07	1.79E-07	4	Vertical
EDC-03-16	6.5-9.4	7.9-8.4	ML	7.60E-07	8.67E-07	8.41E-07	6	Vertical
EDC-03-16	6.5-9.4	8.4-8.9	ML	1.04E-05	1.08E-05	**1.06E-05**	8	**Horizontal**
EDC-03-15	11.5-14.3	12.6-13.1	ML	2.58E-06	5.34E-06	4.45E-06	6	Vertical
EDC-03-15	17.1-20.0	18.0-18.6	CL	5.76E-08	9.25E-08	7.20E-08	4	Vertical
EDC-03-15	17.1-20.0	18.6-19.0	CL	1.20E-06	1.33E-06	**1.25E-06**	5	**Horizontal**
EDC-03-15	22.9-25.8	23.1-23.6	CH	9.27E-09	1.11E-08	2.65E-08	7	Vertical
EDC-03-15	22.9-25.8	23.6-24.2	CH	1.70E-08	5.13E-08	2.66E-08	7	Horizontal
EDC-03-16	3.60-6.50	4.5-5.0	CL	3.91E-07	4.49E-07	4.52E-07	7	Horizontal
EDC-03-16	15.1-18.0	16.3-16.8	SM	3.06E-05	6.68E-05	5.14E-05	12	Vertical
EDC-03-16	20.9-23.8	21.0-21.5	CL	5.25E-06	5.42E-06	5.32E-06	6	Horizontal
EDC-03-17	3.5-6.3	4.8-5.3	CL	3.40E-06	3.77E-06	3.65E-06	5	Vertical
EDC-03-17	9.3-12.2	10.3-10.7	CL	9.31E-07	1.01E-06	9.64E-07	6	Horizontal

Drill Hole	Sample Depth	Specimen Depth	Soil Type	Low K value	High K Value	Average K Value	Number of tests performed	Direction of flow
	ft	ft		cm/sec	cm/sec	cm/sec		
EDC-03-17	9.3-12.2	10.7-11.2	CL	1.42E-06	5.69E-06	**4.62E-06**	4	**Vertical**
EDC-03-17	20.7-23.6	21.0-21.5	CL	5.27E-07	5.54E-07	5.40E-07	6	Vertical
EDC-03-17	29.4-32.5	26.9-27.3	?	3.03E-05	1.45E-04	**1.22E-04**	8	**Horizontal**
EDC-03-17	26.5-29.4	27.3-27.8	ML	8.85E-06	1.04E-05	9.42E-06	7	Vertical
EDC-03-18	3.5-6.4	4.8-5.3	CL	5.81E-08	8.80E-08	7.81E-08	7	Vertical
EDC-03-18	6.4-9.3	6.9-7.4	CL-ML	1.75E-06	7.64E-06	**5.47E-06**	7	**Horizontal**
EDC-03-18	6.4-9.3	7.4-7.9	CL-ML	3.99E-07	5.43E-07	4.31E-07	6	Vertical
EDC-03-18	20.9-23.8	21.8-22.3	CL	7.09E-07	7.95E-07	7.50E-07	7	Vertical
EDC-03-18	23.8-26.7	24.9-25.4	ML	1.24E-06	1.44E-06	1.35E-06	5	Vertical
EDC-03-18	23.8-26.7	24.5-24.9	ML	6.10E-05	1.04E-04	**7.12E-05**	6	**Horizontal**
EDC-04-21	4.3-7.2	4.8-5.3	CL	2.50E-07	2.88E-07	2.66E-07	6	Vertical
EDC-04-21	12.5-15.9	13.9-14.4	CL	1.76E-07	2.30E-07	1.95E-07	6	Vertical
EDC-04-22	3.9-6.9	5.2-5.7	CH	8.05E-08	1.21E-07	9.53E-08	6	Vertical
EDC-04-22	6.9-9.9	7.6-8.0	CH	1.07E-07	1.19E-07	1.11E-07	6	Horizontal
EDC-04-22	6.9-9.9	8.0-8.5	CH	5.12E-07	5.78E-07	5.36E-07	6	Vertical
EDC-04-22	18.9-21.9	19.4-19.9	SM	2.17E-04	2.68E-04	2.41E-04	6	Horizontal
EDC-04-22	18.9-21.9	19.9-20.4	SM	2.14E-04	2.31E-04	2.22E-04	6	Vertical

Drill Hole	Sample Depth	Specimen Depth	Soil Type	Low K value	High K Value	Average K Value	Number of tests performed	Direction of flow
	ft	ft		cm/sec	cm/sec	cm/sec		
EDC-04-24	4.7-7.7	5.3-5.7	CH	2.58E-08	5.62E-08	3.72E-08	4	Horizontal
EDC-04-24	4.7-7.7	5.7-6.2	CH	2.20E-06	4.24E-06	**2.91E-06**	6	**Vertical**
EDC-04-24	13.7-16.7	14.8-15.3	ML	5.68E-06	7.40E-06	**6.42E-06**	10	**Vertical**
EDC-04-24	13.7-16.7	15.3-15.7	ML	1.82E-06	2.59E-06	2.13E-06	6	Horizontal
EDC-04-24	16.7-19.7	17.6-18.1	ML	5.40E-09	5.30E-08	**1.62E-08**	4	**Vertical**
EDC-04-24	16.7-19.7	18.1-18.5	ML	4.60E-09	1.17E-08	6.17E-09	4	Horizontal

Table 6 - Summary of Laboratory Flexible Membrane Permeability Tests # 2 - 2005-2006

Drill Hole	Sample Depth	Specimen Depth	Soil Type	Low K value	High K Value	Average K Value	Direction of flow
	ft	ft		cm/sec	cm/sec	cm/sec	
EDC-05-25	5.4-7.9	5.6-6.1	CL	1.3E-06	8.5E-06	6.9E-06	Vertical
EDC-05-25	5.4-7.9	6.1-6.4	CL	5.6E-05	7.9E-05	6.8E-05	Horizontal
EDC-05-25	8.1-10.6	8.7-9.2	CL	6.8E-07	8.4E-07	7.7E-07	Vertical
EDC-05-25	8.1-10.6	8.3-8.7	CL	1.2E-06	1.2E-06	1.2E-06	**Horizontal**
EDC-05-25	18.9-21.4	19.1-19.6	ML	1.7E-07	2.5E-07	2.2E-07	Horizontal
EDC-05-26	8.2-10.5	9.2-9.7	CH	9.3E-07	1.9E-06	1.3E-06	**Vertical**
EDC-05-26	8.2-10.5	9.7-10.1	CH	5.0E-07	6.0E-07	5.5E-07	Horizontal
EDC-05-26	16.2-18.7	17.1-17.6	CL	1.4E-06	1.7E-06	1.6E-06	Vertical
EDC-05-26	16.2-18.7	17.6-18.0	CL	9.7E-06	1.7E-05	1.4E-05	**Horizontal**
EDC-05-27	5.4-7.9	6.1-6.5	CL	1.6E-06	1.7E-06	1.7E-06	Horizontal
EDC-05-27	5.4-7.9	6.5-7.0	CL	5.1E-05	5.7E-05	5.5E-05	**Vertical**
EDC-05-27	11.0-13.1	11.1-11.5	MH	9.1E-07	1.0E-06	9.8E-07	Horizontal
EDC-05-27	11.0-13.1	11.5-12.0	MH	5.8E-07	6.8E-07	6.2E-07	Vertical
EDC-05-28	2.7-5.2	4.1-4.6	MH	1.5E-07	2.8E-07	2.0E-07	Vertical
EDC-05-28	2.7-5.2	4.6-5.0	MH	2.2E-07	4.1E-07	3.4E-07	Horizontal

Drill Hole	Sample Depth	Specimen Depth	Soil Type	Low K value	High K Value	Average K Value	Direction of flow
	ft	ft		cm/sec	cm/sec	cm/sec	
EDC-05-28	5.4-7.9	6.1-6.6	CL	2.0E-07	3.1E-07	2.4E-07	Vertical
EDC-05-28	5.4-7.9	6.6-7.0	CL	1.3E-06	1.4E-06	1.4E-06	**Horizontal**
EDC-05-28	10.8-13.3	12.1-12.6	(CL)s	1.5E-06	1.7E-06	1.6E-06	Vertical
EDC-05-28	10.8-13.3	12.6-13.3	(CL)s	1.9E-05	2.8E-05	2.5E-05	Horizontal
EDC-05-29	2.7-5.2	3.0-3.5	CL	3.5E-07	4.0E-07	3.7E-07	Vertical
EDC-05-29	5.4-7.8	6.0-6.4	CL	3.6E-06	3.8E-06	3.7E-06	**Horizontal**
EDC-05-30	11.9-13.7	13.3-13.7	CL	1.9E-06	2.1E-06	2.0E-06	Horizontal
EDC-05-30	11.9-13.7	12.8-13.3	CL	1.3E-06	1.5E-06	1.4E-06	Vertical
EDC-05-30	17.3-19.8	17.8-18.2	ML	3.8E-06	3.5E-05	2.7E-05	Vertical
EDC-05-30	17.3-19.8	18.2-18.6	ML	4.8E-06	9.2E-05	7.4E-05	Horizontal
EDC-05-31	8.1-10.6	8.2-8.7	CL	1.2E-07	1.8E-07	1.5E-07	Vertical
EDC-05-31	8.1-10.6	8.7-9.1	CL	5.1E-07	9.0E-07	6.3E-07	Horizontal
EDC-05-31	10.8-13.1	12.0-12.4	S(CL)	3.5E-06	5.3E-06	3.9E-06	Horizontal
EDC-05-31	10.8-13.1	12.4-12.9	S(CL)	3.1E-06	3.8E-06	3.3E-06	Vertical
EDC-05-33	5.4-7.8	5.6-6.0	CH	3.4E-06	3.6E-06	3.6E-06	Horizontal
EDC-05-33	5.4-7.8	6.0-6.5	CH	1.4E-05	2.5E-05	1.8E-05	Vertical
EDC-05-33	10.8-13.2	12.5-13.0	CH	5.4E-07	5.7E-07	5.5E-07	Vertical

Drill Hole	Sample Depth	Specimen Depth	Soil Type	Low K value	High K Value	Average K Value	Direction of flow
	ft	ft		cm/sec	cm/sec	cm/sec	
EDC-05-33	10.8-13.2	12.5-13.0	CH	4.0E-06	5.0E-06	4.6E-06	**Horizontal**
EDC-05-33	13.5-16.0	15.4-15.8	MH	5.0E-06	1.5E-05	1.3E-05	Horizontal

Table 7 - Comparison of Pneumatic Slug and Laboratory Flexible Membrane Hydraulic Conductivities.

P Slug Tests				Laboratory Flexible Membrane Test			
Drill Hole	Soil Type	Depth-ft	K –cm/sec	Drill Hole	Soil Type	Depth -ft	K-cm/sec
ESS-05-25	(CL)s		6.3E-04				
ESS-05-25	s(CL)	12.0-13.0	5.8E-03	EDC-05-25	CL	8.3-8.7	1.2E-06
ESS-05-25	CL	18.0-19.0	7.9E-03	EDC-05-25	ML	19.1-19.6	2.2E-07
ESS-05-26	CL	8.3-9.3	3.3E-04	EDC-05-26	CL	9.7-10.1	1.4E-05
ESS-05-27	CH	11.0-12.0	6.3E-05	EDC-05-27	MH	11.1-11.5	9.8E-07
ESS-05-27	s(CL)	14.4-15.4	3.5E-03				
ESS-05-27	s(ML)	17.0-18.0	6.5E-04				
ESS-05-28	CL	10.0-11.0	5.1E-04				
ESS-05-28	s(CL)	13.5-14.5	1.8E-04	EDC-05-28	(CL)s	12.6-13.3	2.5E-05
ESS-05-28	s(ML)	15.6-16.6	1.2E-03				
ESS-05-29	(CL)s	5.1-6.1	8.6E-04	EDC-05-29	CL	6.0-6.4	3.7E-06
ESS-05-29	s(ML)	8.5-9.5	3.3E-04				
ESS-05-29	CL	13.5-14.5	2.4E-04				
ESS-05-30	CL	11.0-12.0	2.4E-03	EDC-05-30	CL	13.3-13.7	2.0E-06
ESS-05-30	(ML)s	18.0-19.0	1.5E-02				
ESS-05-31	(CL)s	12.0-13.0	7.6E-03	EDC-05-31	s(CL)	12.0-12.4	3.9E-06
ESS-05-31	(CL)s	14.0-15.0	4.7E-03				
ESS-05-31	(CL)s	17.0-18.0	2.1E-03				
ESS-05-33	s(ML)	10.0-11.0	2.0E-04				
ESS-05-33	CL	11.0-12.0	2.5E-04	EDC-05-33	CH	12.5-13.0	4.6E-06

P Slug Tests				Laboratory Flexible Membrane Test			
Drill Hole	Soil Type	Depth-ft	K –cm/sec	Drill Hole	Soil Type	Depth -ft	K-cm/sec
ESS-05-33	(ML)s	13.2-14.2	5.7E-04				
ESS-05-33	CH	15.0-16.0	4.5E-05				

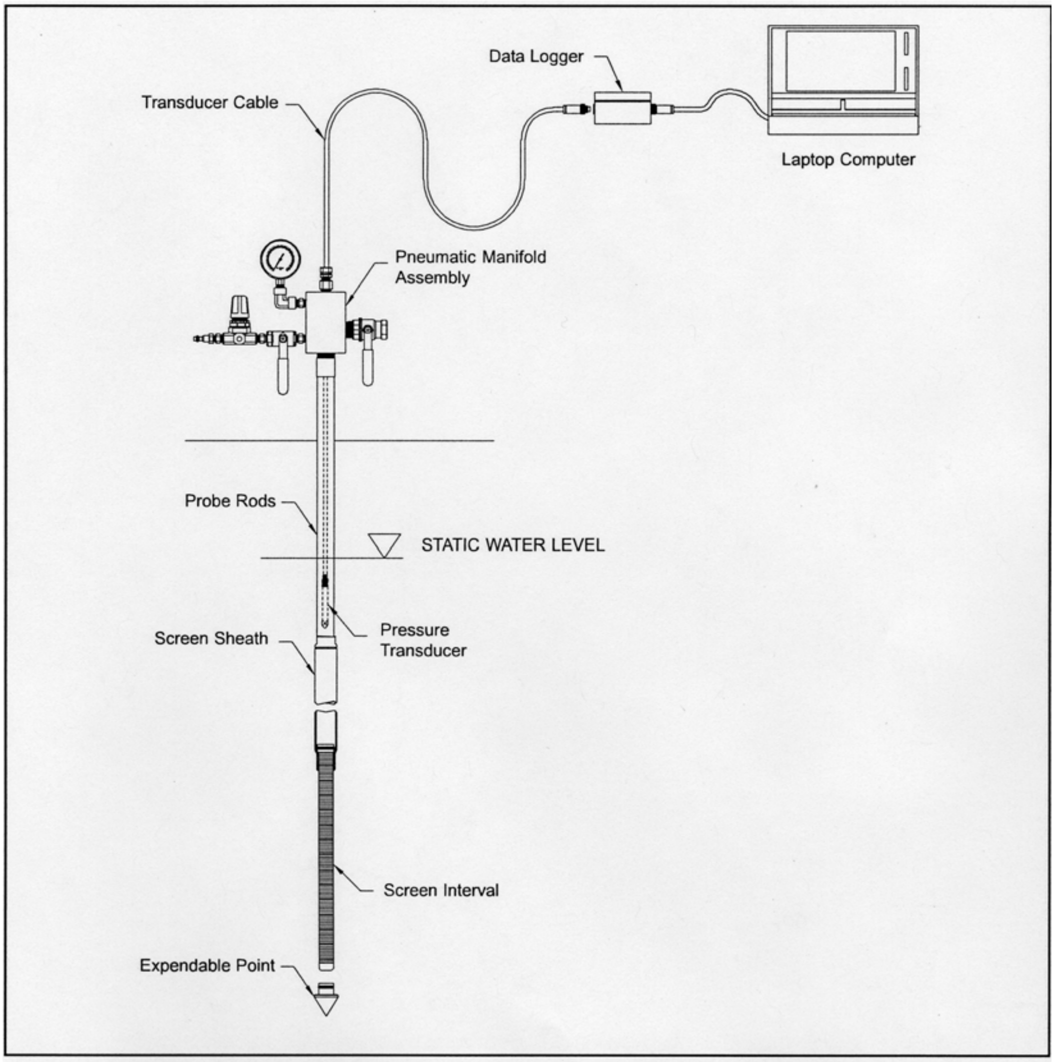


Figure 1 San Luis Drain
Evaporation Pond and Reuse Areas

Geoprobe Pneumatic Slug Test Diagram

Schematic depicts all the parts to the Geoprobe Pneumatic Slug Test. A field computer is connected to a data logger. A transducer connected to the data logger is lowered down the pneumatic manifold assembly. The transducer is lowered below static water level inside square threaded PVC rods. A PVC slotted screen with a one foot interval is located at the bottom of the PVC rods.

Geoprope Standard Operating Procedure February 2002
Technical Bulletin No. 19344

Figure 2 - Photograph of blocky soil structure in clayey soils.

Figure 3 Anisotropy ratios by area.

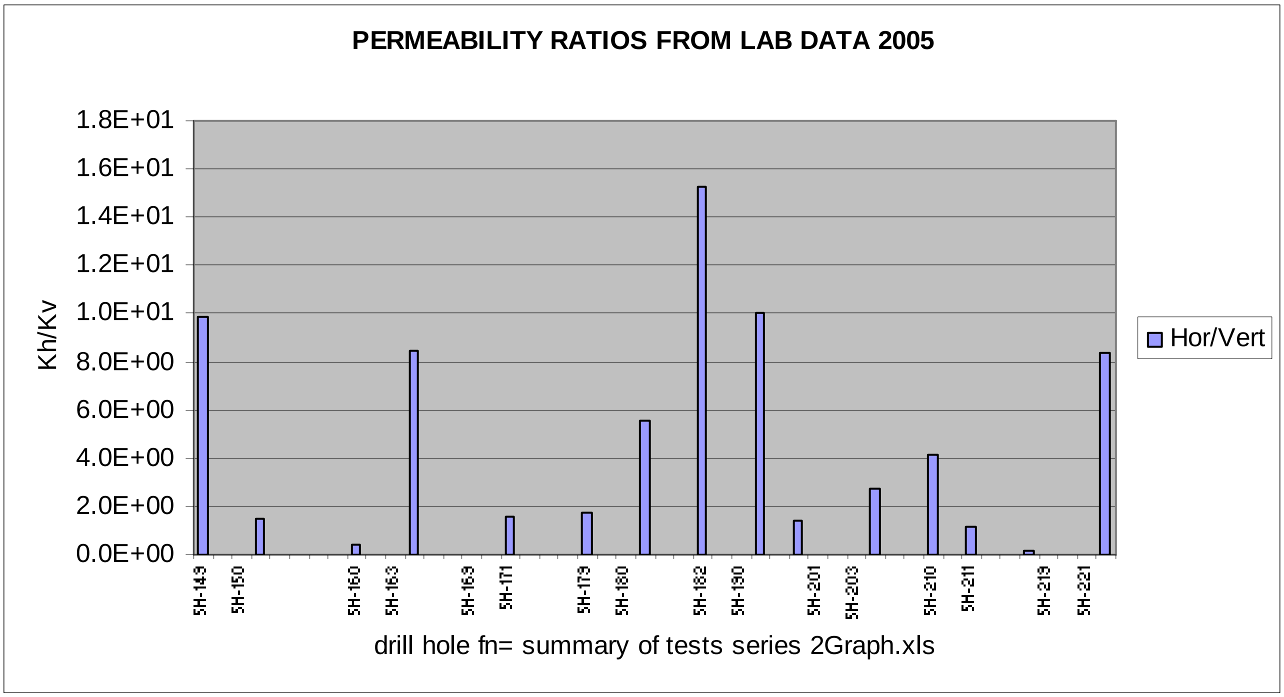


Figure 4 Anisotropy ratios by test

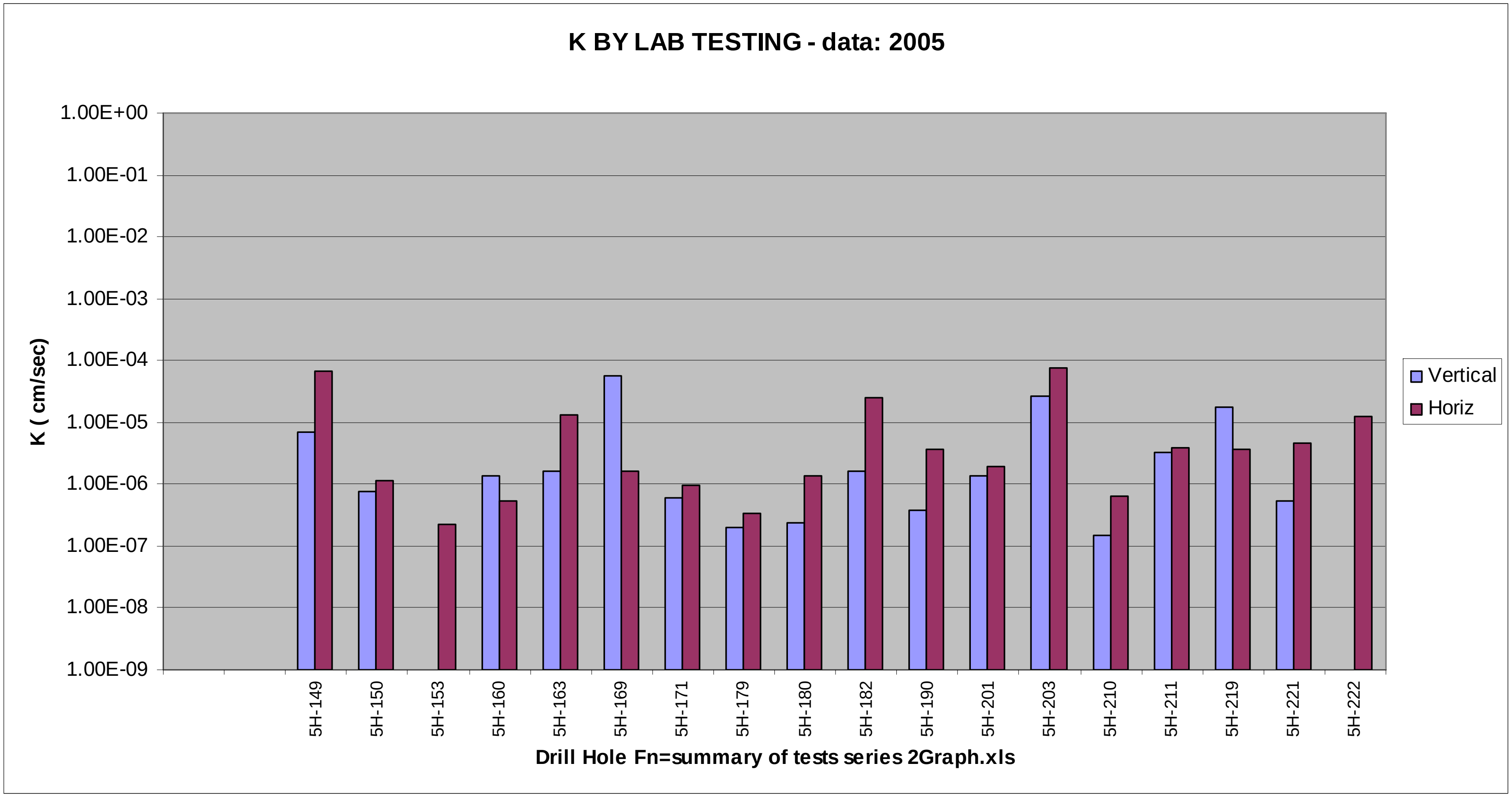
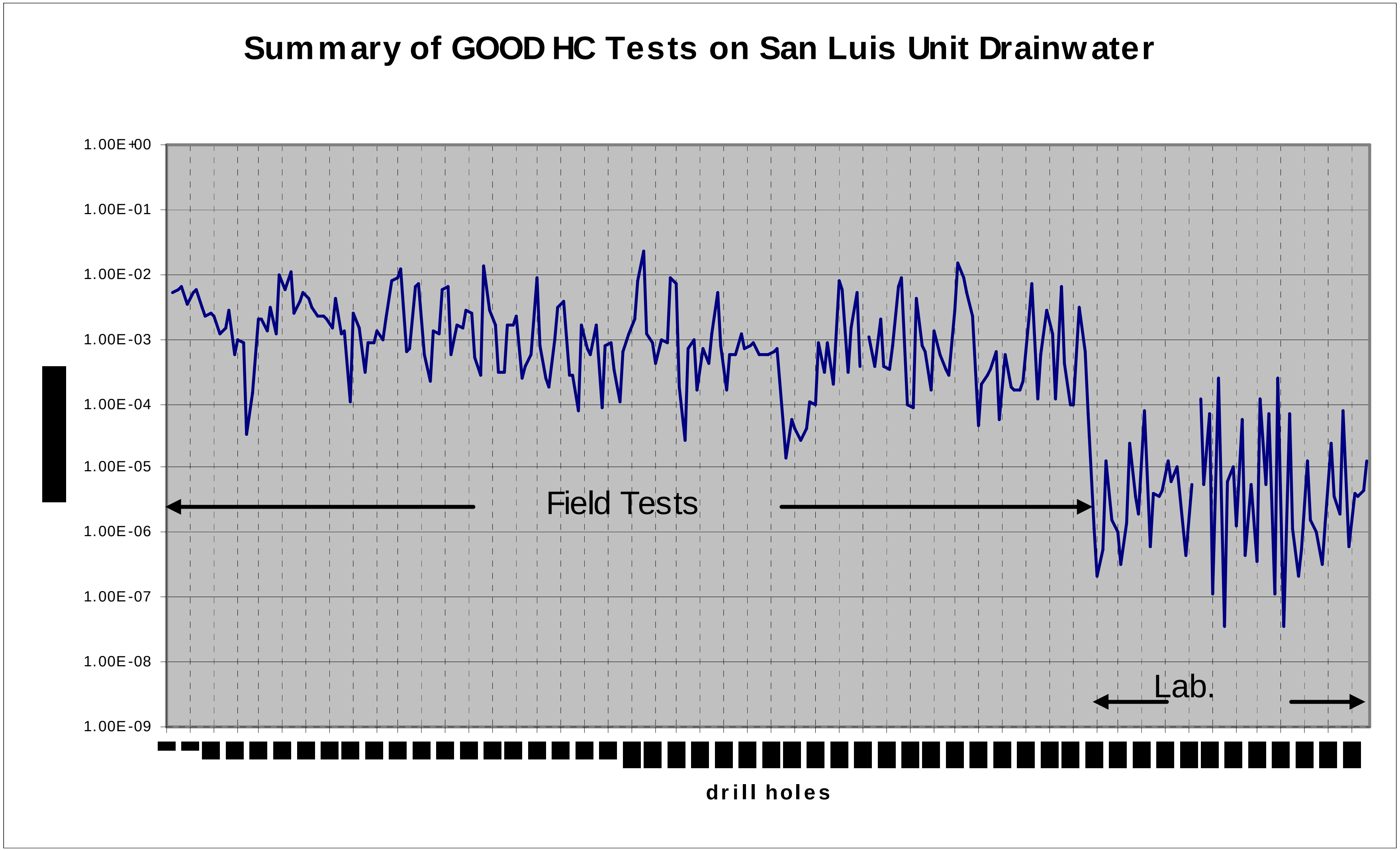


Figure 5 Comparison of field and laboratory data


Summary of GOOD HC Tests on San Luis Unit Drainwater
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
1.00E-08
1.00E-09
Field Tests
Lab.
drill holes

Appendix A

Examples of the Pneumatic Slug Test Software Output

STA version 1.0

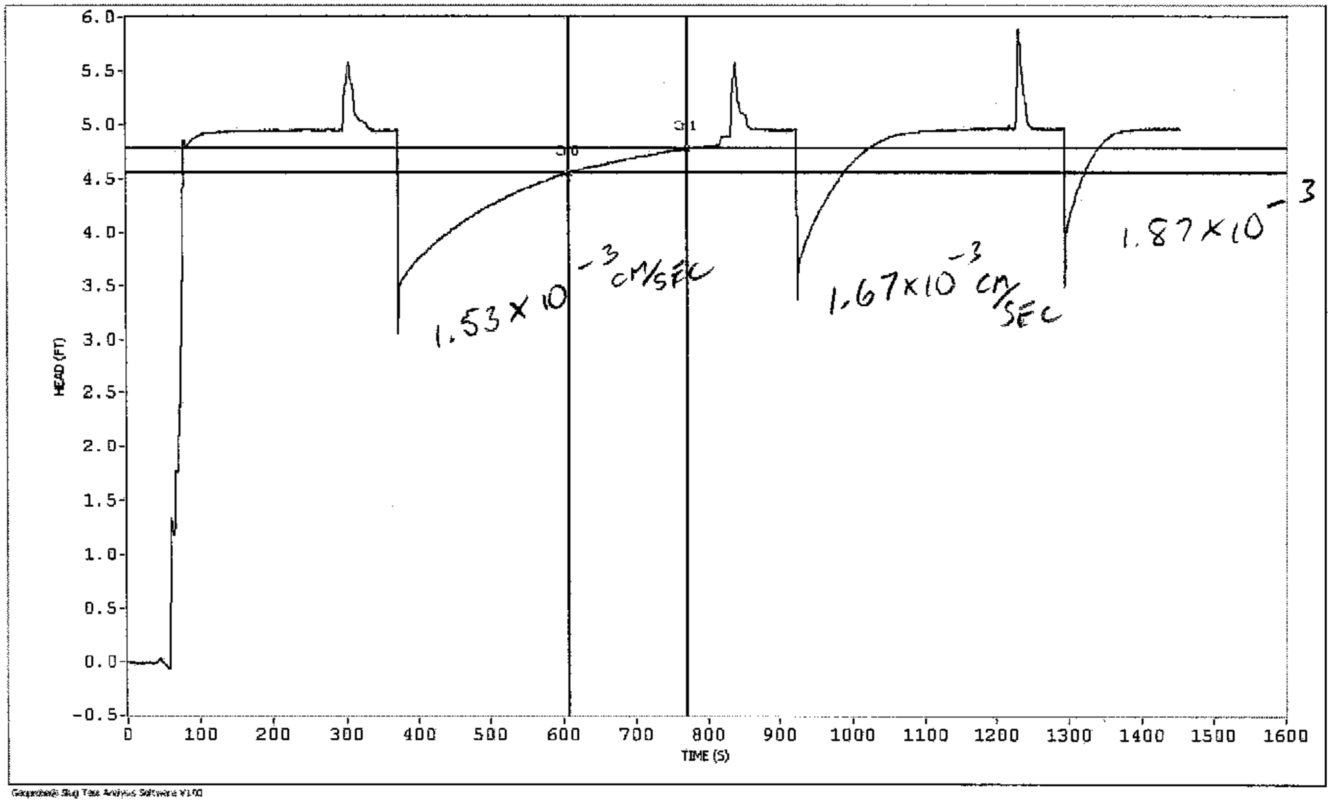
ESS05-25A 9.0 to 10.0 ft 10^{-4} cm/sec

ESS05-25B 12.0-13.0 ft 10^{-3} cm/sec

ESS05-28A 13.5-14.5 ft 10^{-5} cm/sec

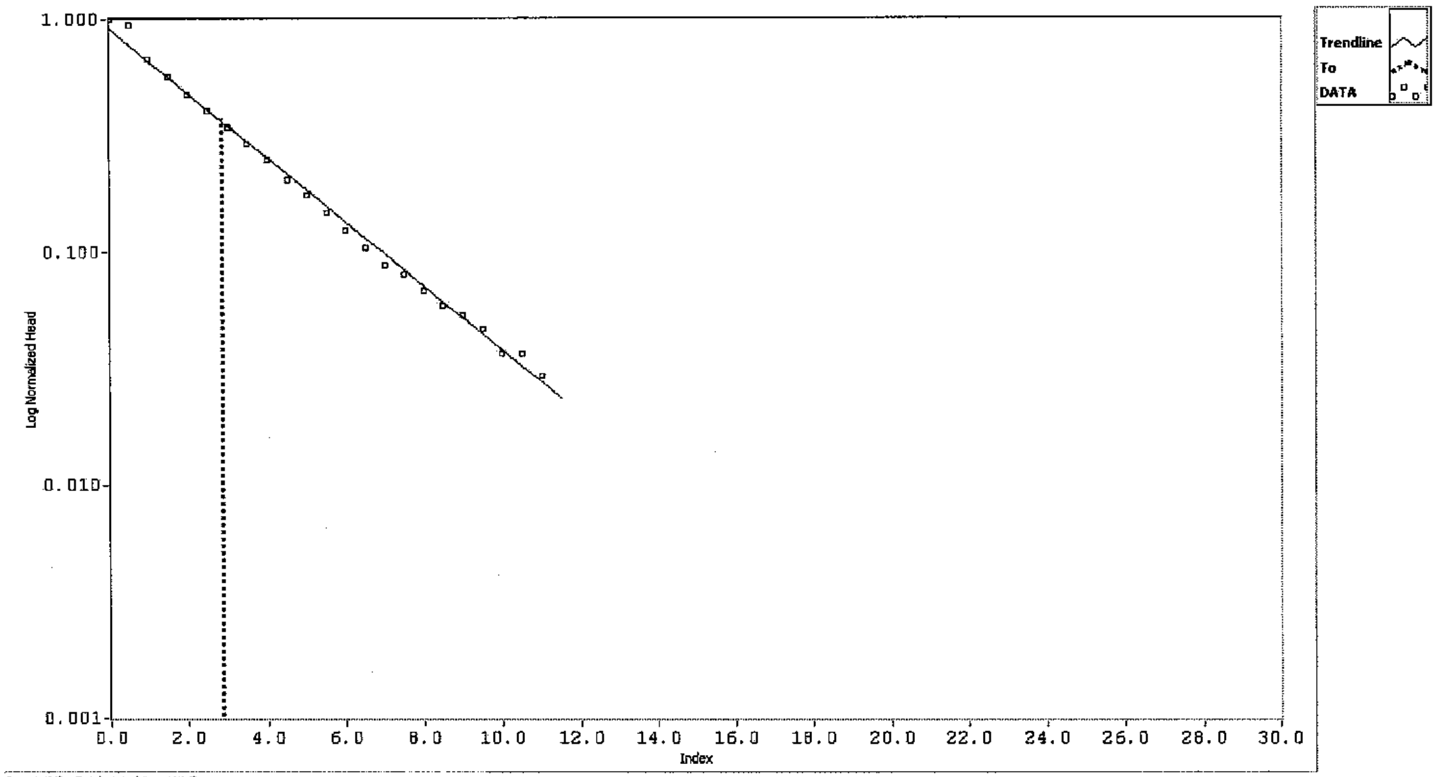
ESS05-28B 14.2-15.2 ft 10^{-5} to 10^{-6} cm/sec

Log Data Set
File Name: C:\dirim95\ESS28-B.dat Printed: Thursday, March 02, 2006 12:37:03



ESS25B 12-13'

Interval Data Set
Interval: 619.500 Sec to 638.000 Sec
File Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25B-1 unconf .inv Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25--B.dat
Printed: Thursday, March 02, 2006 12:37:29



Log | Interval | INF | Parameter | Documentation/Reports

Required in Red — **Well Construction Parameters**

Le (ft)	1.000	rt (in)	0.113
Ls (ft)	1.000	SWL (ft)	7.100
Lw (ft)	5.900	TD (ft)	13.000
Rs (in)	-1.000	H (ft)	6.400
Rb (in)	0.500	Ho (in)	-1.000
Rc (in)	0.250	Well	Fully Penetrating

Site Data

Site Name:	Evap Pond B
Project #:	San Luis Drain
Well #:	E55-05-25 (B-1)
Test #:	E5525B1 (12.0-
Location:	Yuba Ave
Date:	9/23/05
Field Tech:	J. Vauk
Analyst:	J. Vauk and G.

Log Name
C:\dirim95\logfiles\San Luis Drain\evap B\E55-05-25\E5525--B.dat

Interval Name
C:\dirim95\logfiles\San Luis Drain\evap B\E55-05-25\E5525B-1 unconf .inv

Start Time	End Time
619.500	638.000

Analysis

Response	Log
Configuration	Confined
Analysis Algorithm	Hvorslev
Baseline (ft)	5.632
t*d/t*	-1.000
Cd	-1.000
K-Correction small dia wells	-1.000

Partially Penetrating Parameters
Where Le/Rb = 24.000
A = -1.000 B = -1.000

Fully Penetrating Parameter
C = -1.000

Log Response Parameters

D Coeff	-0.318	R-squared	9.53E-1
Amplitude	0.910	To	2.848

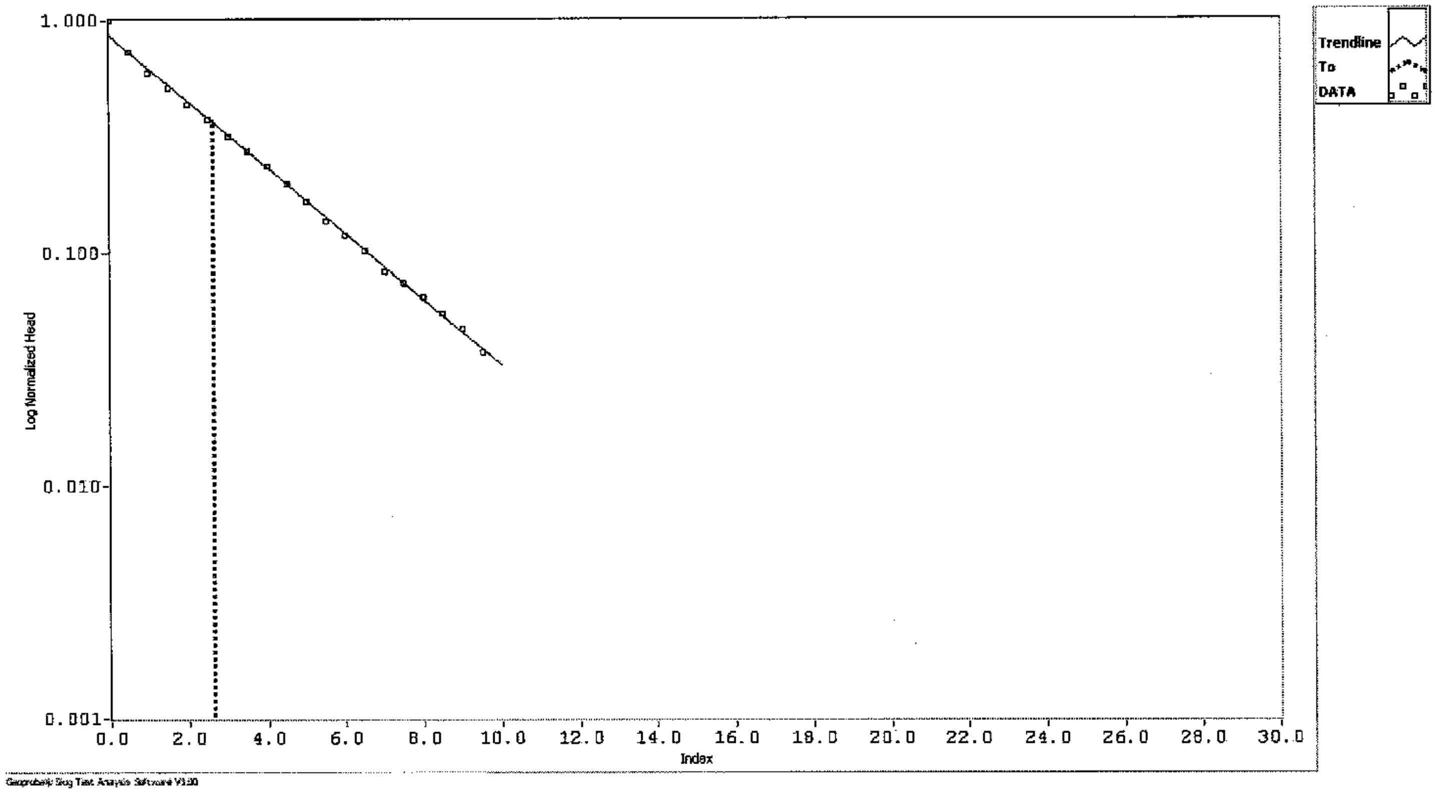
Calculated K

K (FT/Day)	4.336
K (cm/Sec)	1.530E-3
Well	Fully Penetrating

Documentation and Reports

View Parameter Graphic
View Parameter Definitions
Print This Page

Interval Data Set
Interval: 761.000 Sec to 782.500 Sec
File Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25B-2 unconf .inv Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25--B.dat
Printed: Thursday, March 02, 2006 12:37:57



Log | Interval | INF | Parameter | Documentation/Reports

Required in Red **Well Construction Parameters**

Le (ft)	1.000	rt (in)	0.113
Ls (ft)	1.000	SWL (ft)	7.100
Lw (ft)	5.900	TD (ft)	13.000
Rs (in)	-1.000	H (ft)	6.400
Rb (in)	0.500	Ho (in)	-1.000
Rc (in)	0.250	Well	Fully Penetrating

Site Data

Site Name:	Evap Pond B
Project #:	San Luis Drain
Well #:	ES5-05-25 (B-2)
Test #:	ES525B2 (12.0-
Location:	Yuba Ave
Date:	9/23/05
Field Tech:	J. Vauk
Analyst:	J. Vauk and G.

Log Name
C:\dirim95\logfiles\San Luis Drain\evap B\ES5-05-25\ES525--B.dat

Interval Name
C:\dirim95\logfiles\San Luis Drain\evap B\ES5-05-25\ES525B-2 unconf .inv

Start Time	End Time
761.000	782.500

Analysis

Response	Log
Configuration	Confined
Analysis Algorithm	Hvorslev
Baseline (ft)	5.630
t*d/t*	-1.000
Cd	-1.000
K-Correction small dia wells	-1.000

Partially Penetrating Parameters
Where Le/Rb = 24.000
A = -1.000 B = -1.000

Fully Penetrating Parameter
C = -1.000

Log Response Parameters

D Coeff	-0.327	R-squared	9.47E-1
Amplitude	0.861	To	2.603

Calculated K

K (FT/Day)	4.745
K (cm/Sec)	1.674E-3
Well	Fully Penetrating

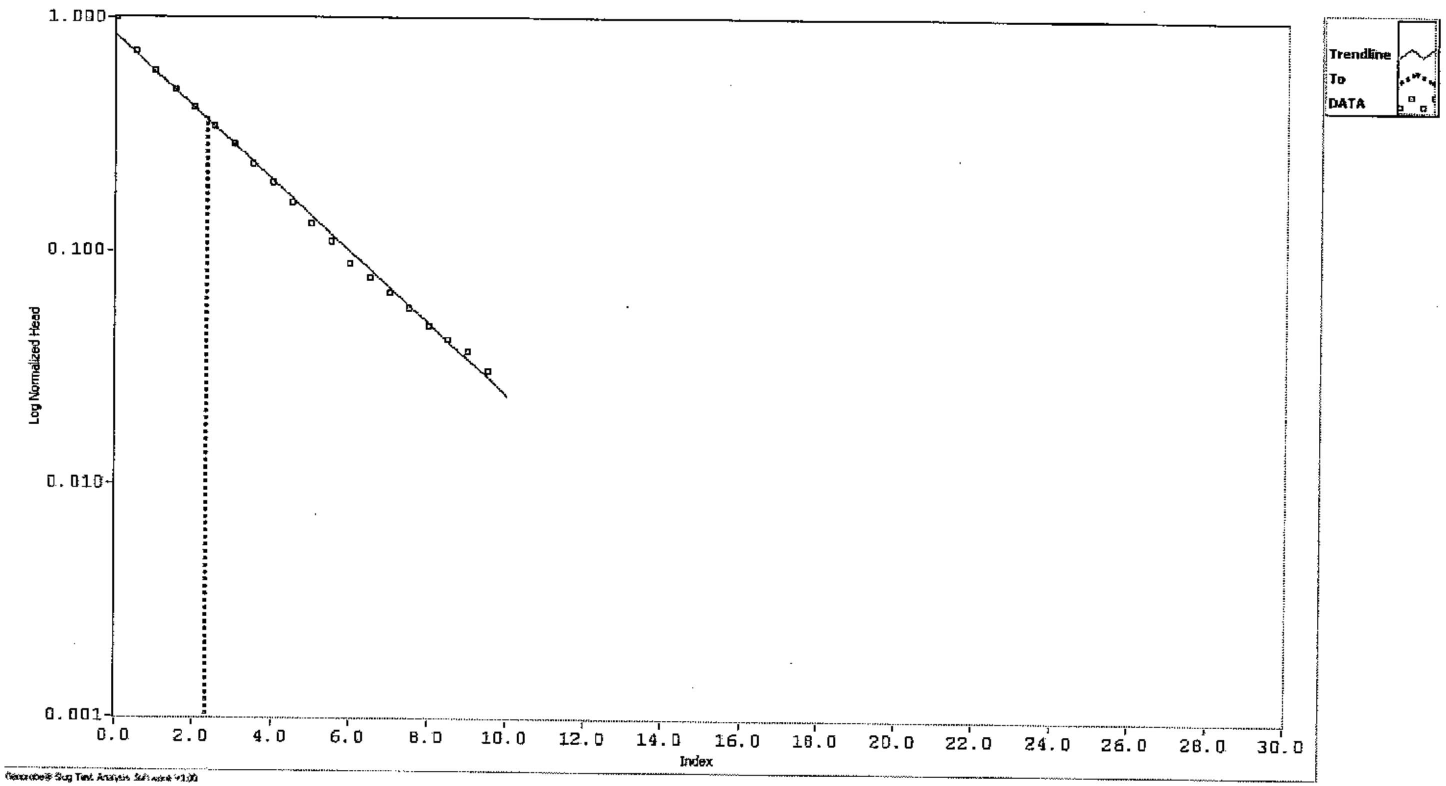
Documentation and Reports

View Parameter Graphic

View Parameter Definitions

Print This Page

Interval Data Set
Interval: 1167.000 Sec to 1182.500 Sec
File Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25B-3 unconf .inv Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25--B.dat
Printed: Thursday, March 02, 2006 12:38:20



Log | Interval | INF | Parameter | Documentation/Reports

Required in Red — **Well Construction Parameters**

Le (ft)	1.000	rt (in)	0.113
Ls (ft)	1.000	SWL (ft)	7.100
Lw (ft)	5.900	TD (ft)	13.000
Rs (in)	-1.000	H (ft)	6.400
Rb (in)	0.500	Ho (in)	-1.000
Rc (in)	0.250	Well	Fully Penetrating

Site Data

Site Name:	Evap Pond B
Project #:	San Luis Drain
Well #:	E55-05-25 (B-3)
Test #:	E552583 (12.0-
Location:	Yuba Ave
Date:	9/23/05
Field Tech:	J. Vauk
Analyst:	J. Vauk and G.

Log Name
C:\dirim95\logfiles\San Luis Drain\evap B\E55-05-25\E5525--B.dat

Interval Name
C:\dirim95\logfiles\San Luis Drain\evap B\E55-05-25\E55258-3 unconf .inv

Start Time	End Time
1167.000	1182.500

Analysis

Response: Log
Configuration: Confined
Analysis Algorithm: Hvorslev
Baseline (ft): 5.656
t*d/t*: -1.000 Cd: -1.000
K-Correction small dia wells: -1.000

Partially Penetrating Parameters

Where Le/Rb = 24.000
A = -1.000 B = -1.000

Fully Penetrating Parameter

C = -1.000

Log Response Parameters

D Coeff: -0.355 R-squared: 9.47E-1
Amplitude: 0.841 To: 2.327

Calculated K

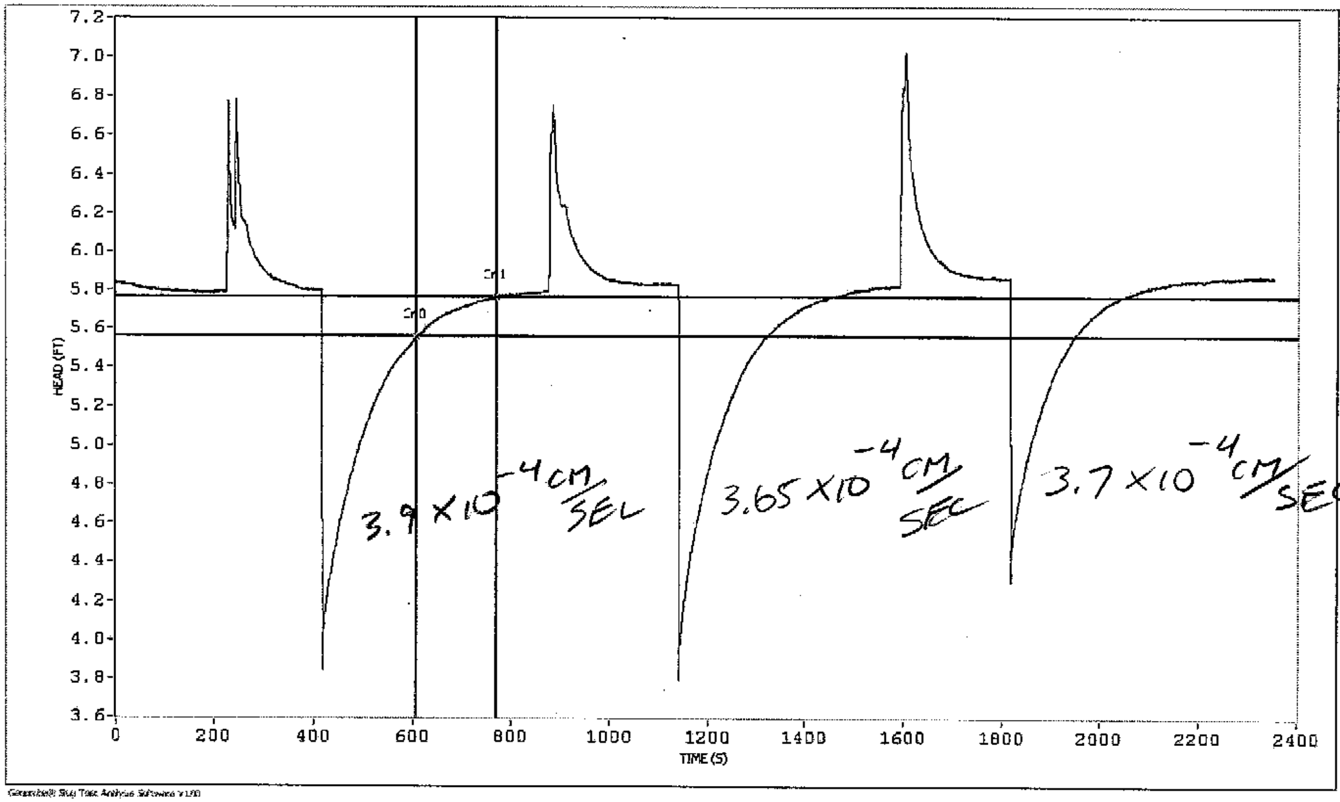
K (FT/Day): 5.307
K (cm/Sec): 1.872E-3
Well: Fully Penetrating

Documentation and Reports

View Parameter Graphic
View Parameter Definitions
Print This Page

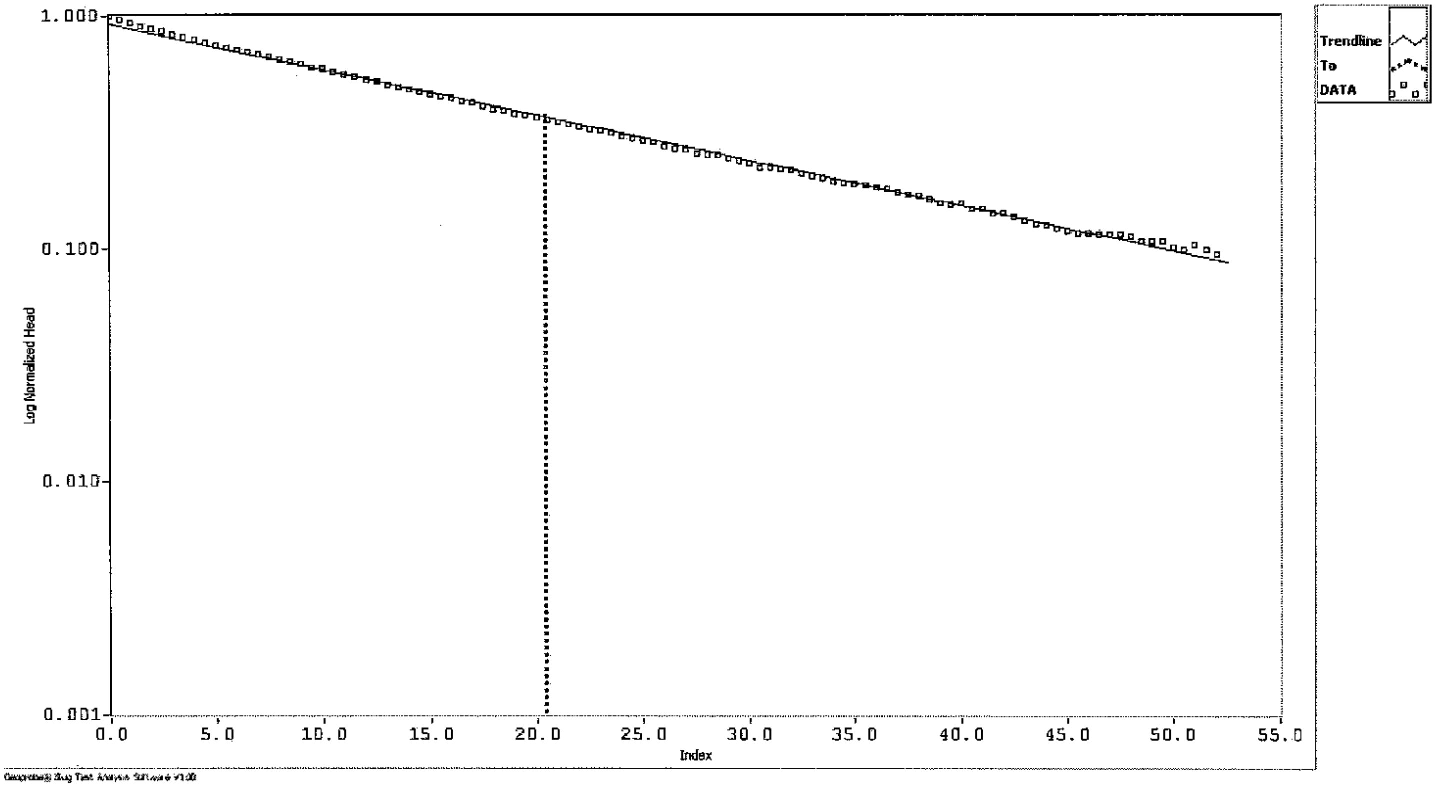
Log Data Set

File Name: C:\dirim95\ESS28-A.dat Printed: Thursday, March 02, 2006 12:42:10



ESS25 A 9-10'

Interval Data Set
Interval: 582.000 Sec to 680.500 Sec
File Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25A-1 unconf..inv Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25A.dat
Printed: Thursday, March 02, 2006 12:42:27



Log | Interval | TNF | Parameter | Documentation/Reports

Required In Red **Well Construction Parameters**

Le (ft)	1.000	rt (in)	0.113
Ls (ft)	1.000	SWL (ft)	7.100
Lw (ft)	2.900	TD (ft)	10.000
Rs (in)	-1.000	H (ft)	3.500
Rb (in)	0.500	Ho (in)	-1.000
Rc (in)	0.250	Well	Fully Penetrating

Site Data

Site Name:	EVAP POND B
Project #:	San Luis Drain
Well #:	ES5-05-25 (A-1)
Test #:	ES525A1 (9.0-10.0)
Location:	Yuba Ave.
Date:	9/23/05
Field Tech:	J. Vauk and T.
Analyst:	J. Vauk and G.

Log Name

C:\dirim95\logfiles\San Luis Drain\evap B\ES5-05-25\ES525A.dat

Interval Name

C:\dirim95\logfiles\San Luis Drain\evap B\ES5-05-25\ES525A-1 unconf..inv

Start Time	End Time
582.000	680.500

Analysis

Response	Log
Configuration	Confined
Analysis Algorithm	Hvorslev
Baseline (ft)	3.031
t*d/t*	-1.000
Cd	-1.000
K-Correction small dia wells	-1.000

Partially Penetrating Parameters

Where Le/Rb = 24.000

A = -1.000 B = -1.000

Fully Penetrating Parameter

C = -1.000

Log Response Parameters

D Coeff	-0.045	R-squared	9.89E-1
Amplitude	0.918	To	20.394

Calculated K

K (FT/Day)	1.107
K (cm/Sec)	3.907E-4
Well	Fully Penetrating

Documentation and Reports

View Parameter Graphic

View Parameter Definitions

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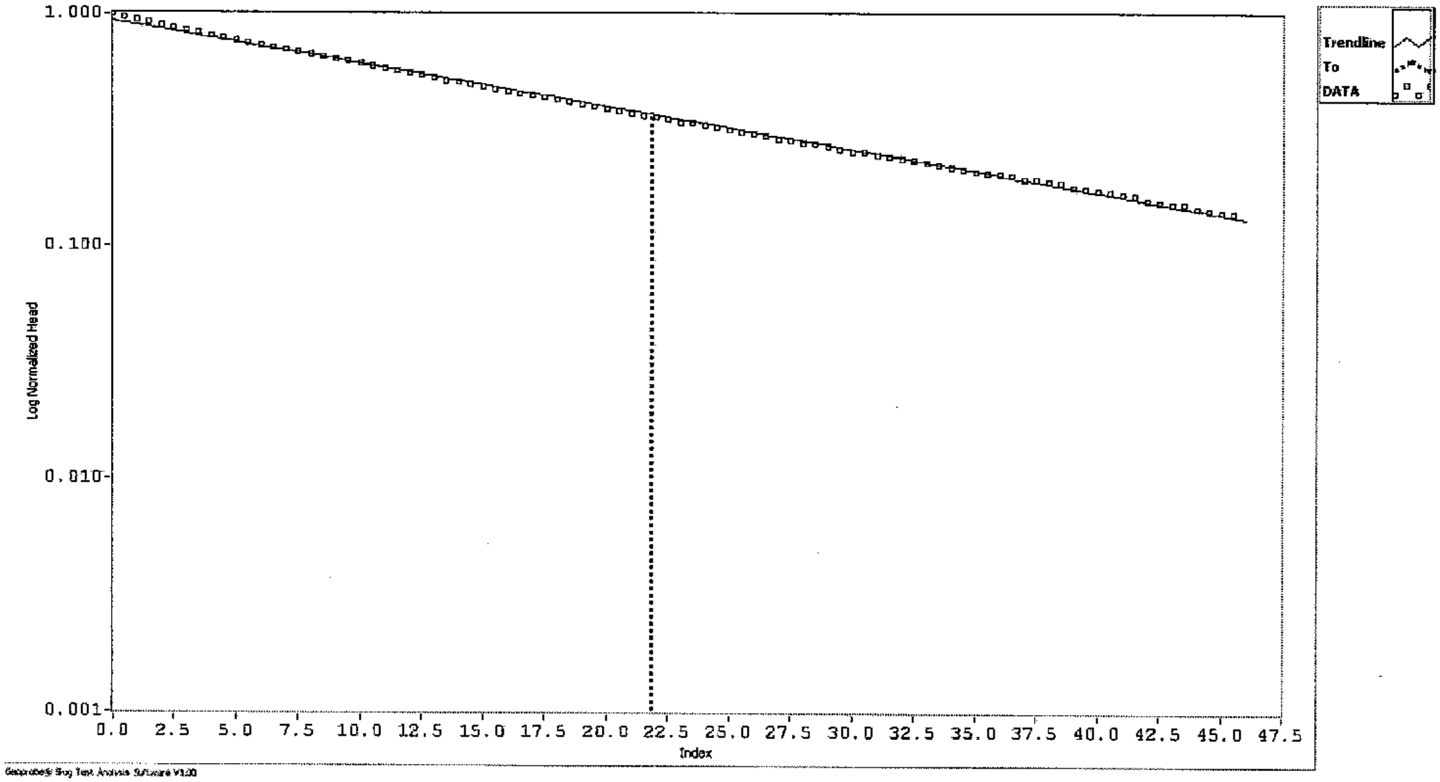
Interval Data Set
Interval: 949.000 Sec to 1049.000 Sec
File Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25A-2 unconf .inv Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25A.dat
Printed: Thursday, March 02, 2006 12:42:48



Log | Interval | INF | Parameter | Documentation/Reports

Required in Red **Well Construction Parameters**

Le (ft)	1.000	rt (in)	0.113
Ls (ft)	1.000	SWL (ft)	7.100
Lw (ft)	2.900	TD (ft)	10.000
Rs (in)	-1.000	H (ft)	3.500
Rb (in)	0.500	Ho (in)	-1.000
Rc (in)	0.250	Well	Fully Penetrating

Site Data

Site Name:	EVAP POND 8
Project #:	San Luis Drain
Well #:	ES5-05-25 (A-2)
Test #:	ES525A2 (9.0-10.0)
Location:	Yuba Ave.
Date:	9/23/05
Field Tech:	J. Vauk and T.
Analyst:	J. Vauk and G.

Log Name
C:\dirim95\logfiles\San Luis Drain\evap 8\ES5-05-25\ES525A.dat

Interval Name
C:\dirim95\logfiles\San Luis Drain\evap 8\ES5-05-25\ES525A-2 unconf .inv

Start Time 949.000 **End Time** 1049.000

Analysis

Response Log
Configuration Confined
Analysis Algorithm Hvorslev
Baseline (ft) 3.067
t*d/t* -1.000 **Cd** -1.000
K-Correction small dia wells -1.000

Partially Penetrating Parameters
Where Le/Rb = 24.000
A = -1.000 **B =** -1.000

Fully Penetrating Parameter
C = -1.000

Log Response Parameters
D Coeff -0.043 **R-squared** 9.88E-1
Amplitude 0.936 **To** 21.813

Calculated K
K (FT/Day) 1.035
K (cm/Sec) 3.653E-4
Well Fully Penetrating

Documentation and Reports

View Parameter Graphic
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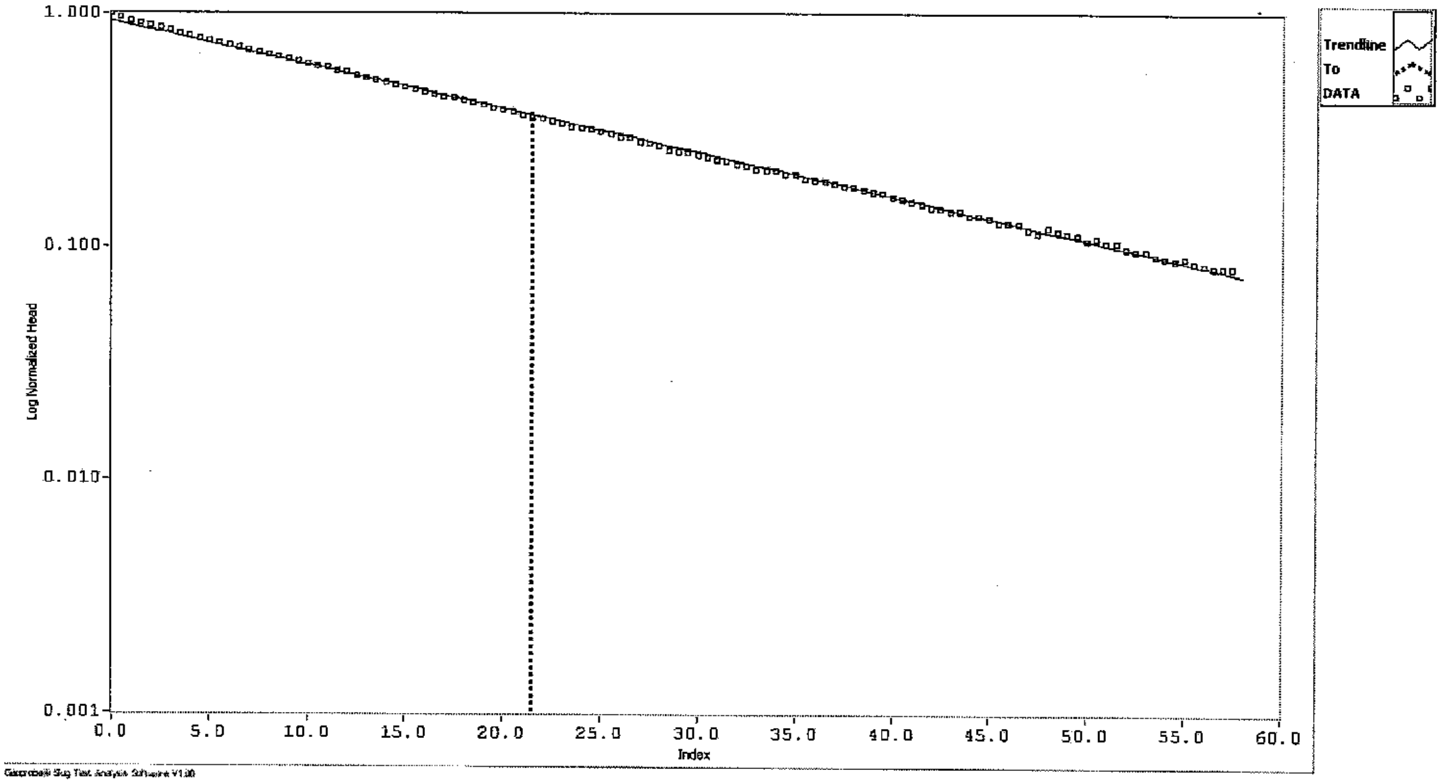
Interval Data Set
Interval: 1311.500 Sec to 1432.000 Sec
File Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25A-3 unconf .inv Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25A.dat
Printed: Thursday, March 02, 2006 12:43:24



Log | Interval | INF | Parameter | Documentation/Reports

Required in Red — **Well Construction Parameters**

Le (ft)	1.000	rt (in)	0.113
Ls (ft)	1.000	SWL (ft)	7.100
Lw (ft)	2.900	TD (ft)	10.000
Rs (in)	-1.000	H (ft)	3.500
Rb (in)	0.500	Ho (in)	-1.000
Rc (in)	0.250	Well	Fully Penetrating

Site Data

Site Name:	EVAP POND B
Project #:	San Luis Drain
Well #:	ESS-05-25 (A-3)
Test #:	ESS25A3 (9.0-10.0)
Location:	Yuba Ave.
Date:	9/23/05
Field Tech:	J. Vauk and T.
Analyst:	J. Vauk and G.

Log Name
C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25A.dat

Interval Name
C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-25\ESS25A-3 unconf .inv

Start Time	End Time
1311.500	1432.000

Analysis

Response	Log
Configuration	Confined
Analysis Algorithm	Hvorslev
Baseline (ft)	3.066
t*d/t*	-1.000
Cd	-1.000
K-Correction small dia wells	-1.000

Partially Penetrating Parameters

Where Le/Rb = 24.000

A = -1.000 B = -1.000

Fully Penetrating Parameter

C = -1.000

Log Response Parameters

D Coeff	-0.043
R-squared	9.91E-1
Amplitude	0.932
To	21.467

Calculated K

K (FT/Day)	1.052
K (cm/Sec)	3.712E-4
Well	Fully Penetrating

Documentation and Reports

View Parameter Graphic

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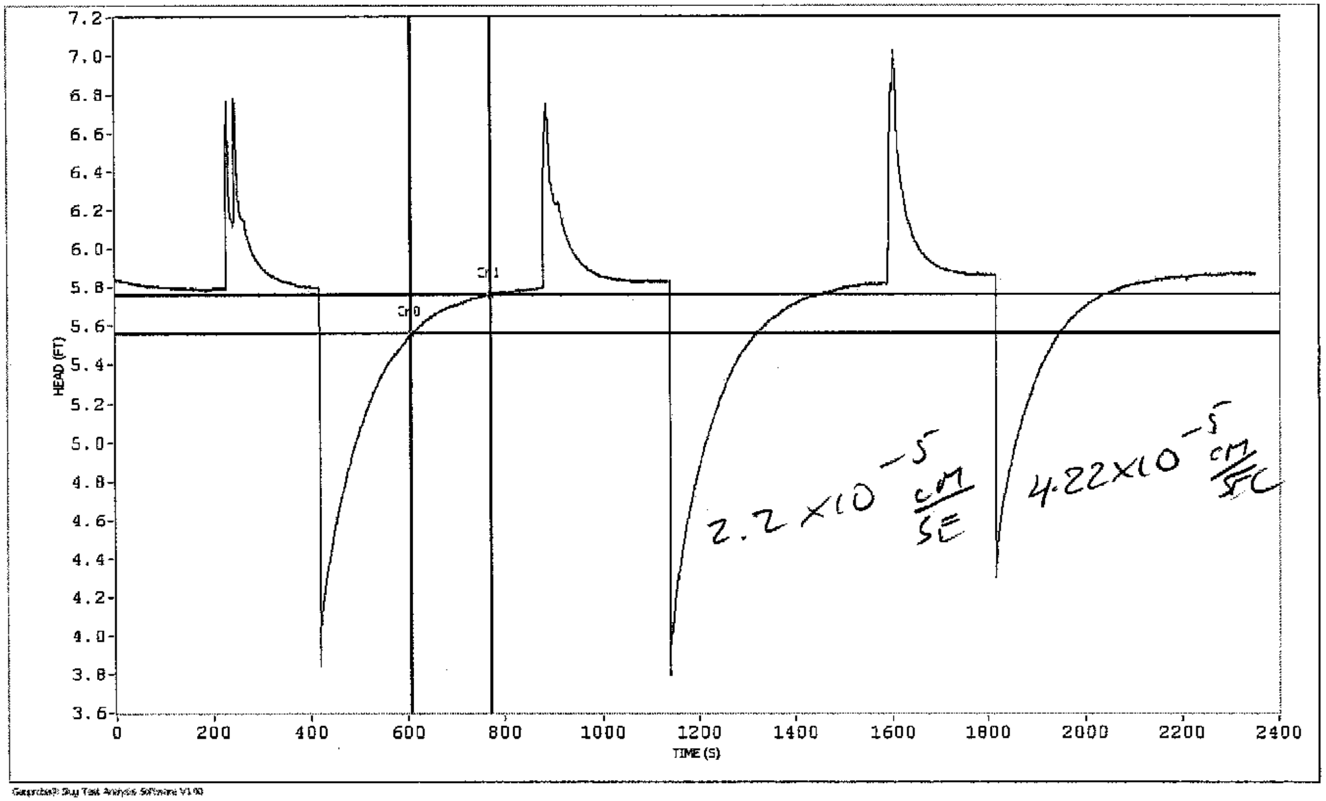
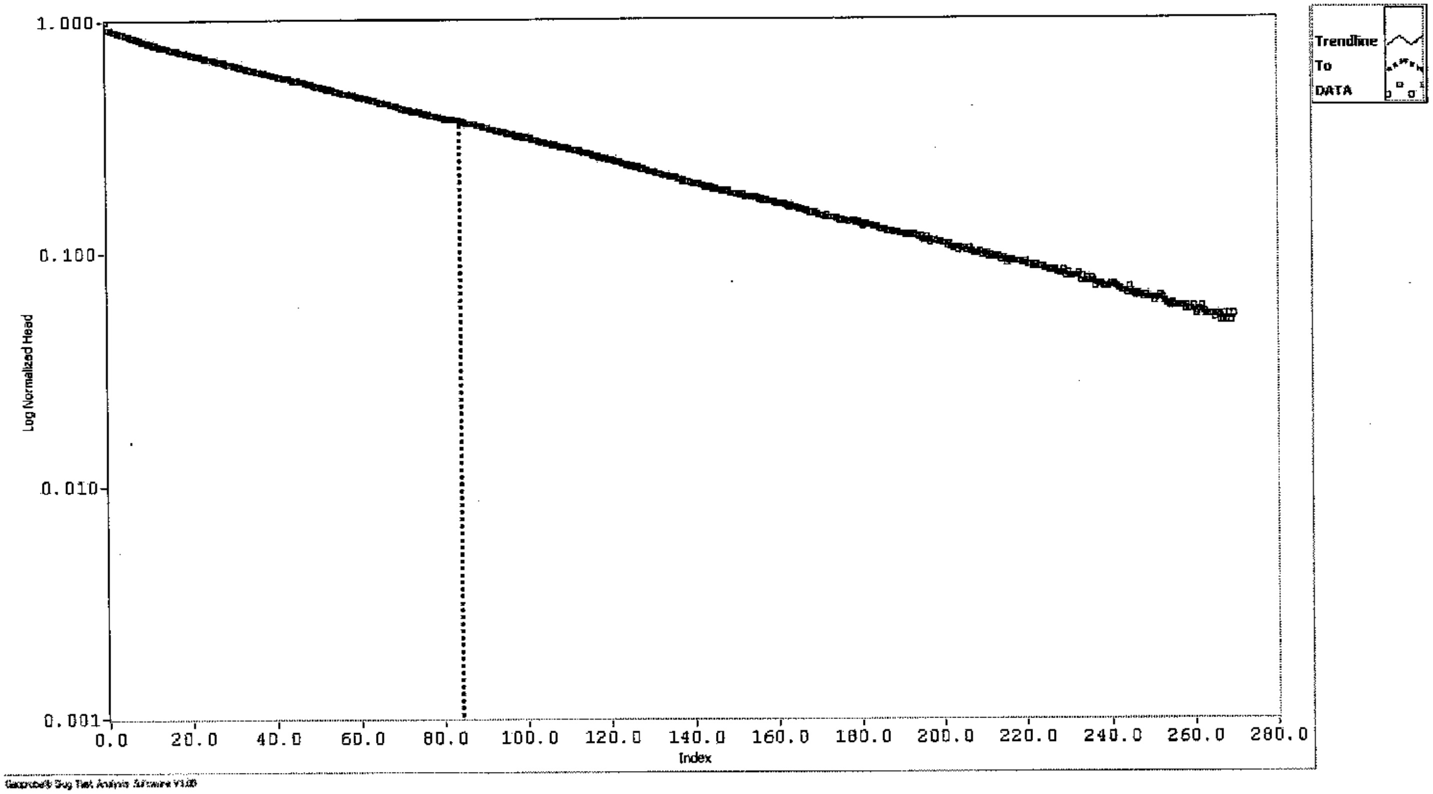
Log Data Set
File Name: C:\dirim95\ESS28-A.dat Printed: Thursday, March 02, 2006 13:22:30



ESS 05 28 A 13.5-14.5

Interval Data Set
Interval: 1141.000 Sec to 1435.000 Sec
File Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-28\ESS28 A-2 unconf .inv Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-28\ESS28-A.dat
Printed: Thursday, March 02, 2006 13:24:31



A-2

Log | Interval | INF | Parameter | Documentation/Reports

Required in Red

Well Construction Parameters

Le (ft)	1.000	rt (in)	0.113
Ls (ft)	1.000	SWL (ft)	4.200
Lw (ft)	10.300	TD (ft)	14.500
Rs (in)	-1.000	H (ft)	15.200
Rb (in)	0.500	Ho (in)	-1.000
Rc (in)	0.250	Well	Fully Penetrating

Site Data

Site Name:	Evap pond B
Project #:	San Luis Drain
Well #:	E55-05-28 (A-2)
Test #:	E5528A-2 (13.5-
Location:	Butte Ave.
Date:	10/6/05
Field Tech:	J. Vauk
Analyst:	J. vauk

Log Name

C:\dirim95\logfiles\San Luis Drain\evap B\E55-05-28\E5528-A.dat

Interval Name

C:\dirim95\logfiles\San Luis Drain\evap B\E55-05-28\E5528 A-2 unconf .inv

Start Time	End Time
1141.000	1435.000

Analysis

Response: Log

Configuration: Confined

Analysis Algorithm: Hvorslev

Baseline (ft): 3.411

t*d/t*: -1.000   Cd: -1.000

K-Correction small dia wells: -1.000

Partially Penetrating Parameters

Where Le/Rb = 24.000

A = -1.000   B = -1.000

Fully Penetrating Parameter

C = -1.000

Log Response Parameters

D Coeff: -0.011   R-squared: 9.98E-1

Amplitude: 0.899   To: 84.123

Calculated K

K (FT/Day): 0.062

K (cm/Sec): 2.181E-5

Well: Fully Penetrating

Documentation and Reports

View Parameter Graphic

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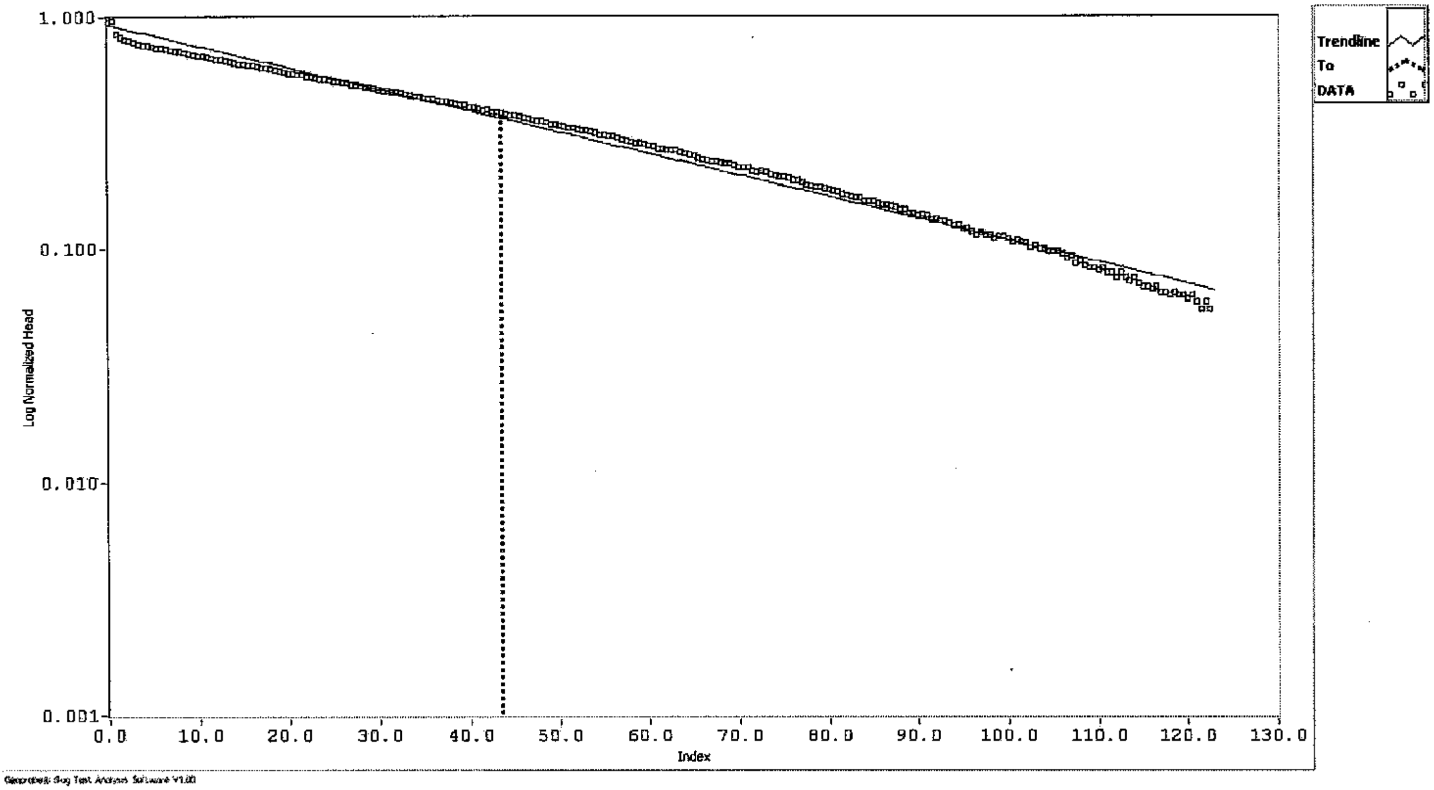
Interval Data Set
Interval: 923.500 Sec to 1192.500 Sec
File Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-28\ESS28 A-3 unconf .inv Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-28\ESS28-B.dat
Printed: Thursday, March 02, 2006 13:25:09



Log | Interval | TNF | Parameter | Documentation/Reports

Required in Red **Well Construction Parameters**

Le (ft)	1.000	rt (in)	0.113
Ls (ft)	-1.000	SWL (ft)	4.200
Lw (ft)	6.800	TD (ft)	11.000
Rs (in)	-1.000	H (ft)	15.200
Rb (in)	0.500	Ho (in)	-1.000
Rc (in)	0.250	Well	Fully Penetrating

Site Data

Site Name:	Evap Pond B
Project #:	San Luis Drain
Well #:	ES5-05-28 (B-2)
Test #:	ES528B-2 (10.0-
Location:	Butte and Cerini
Date:	9/22/05
Field Tech:	J. Vauk
Analyst:	J. Vauk

Log Name
C:\dirim95\logfiles\San Luis Drain\evap B\ES5-05-28\ES528-B.dat

Interval Name
C:\dirim95\logfiles\San Luis Drain\evap B\ES5-05-28\ES528 A-3 unconf .inv

Start Time	End Time
923.500	1192.500

Analysis

Response: Log
Configuration: Confined
Analysis Algorithm: Hvorslev
Baseline (ft): 4.960
t*d/t*: -1.000 Cd: -1.000
K-Correction small dia wells: -1.000

Partially Penetrating Parameters
Where Le/Rb = 24.000
A = -1.000 B = -1.000

Fully Penetrating Parameter
C = -1.000

Log Response Parameters
D Coeff: -0.021 R-squared: 9.91E-1
Amplitude: 0.932 To: 43.439

Calculated K
K (FT/Day): 0.120
K (cm/Sec): 4.223E-5
Well: Fully Penetrating

Documentation and Reports

View Parameter Graphic

View Parameter Definitions

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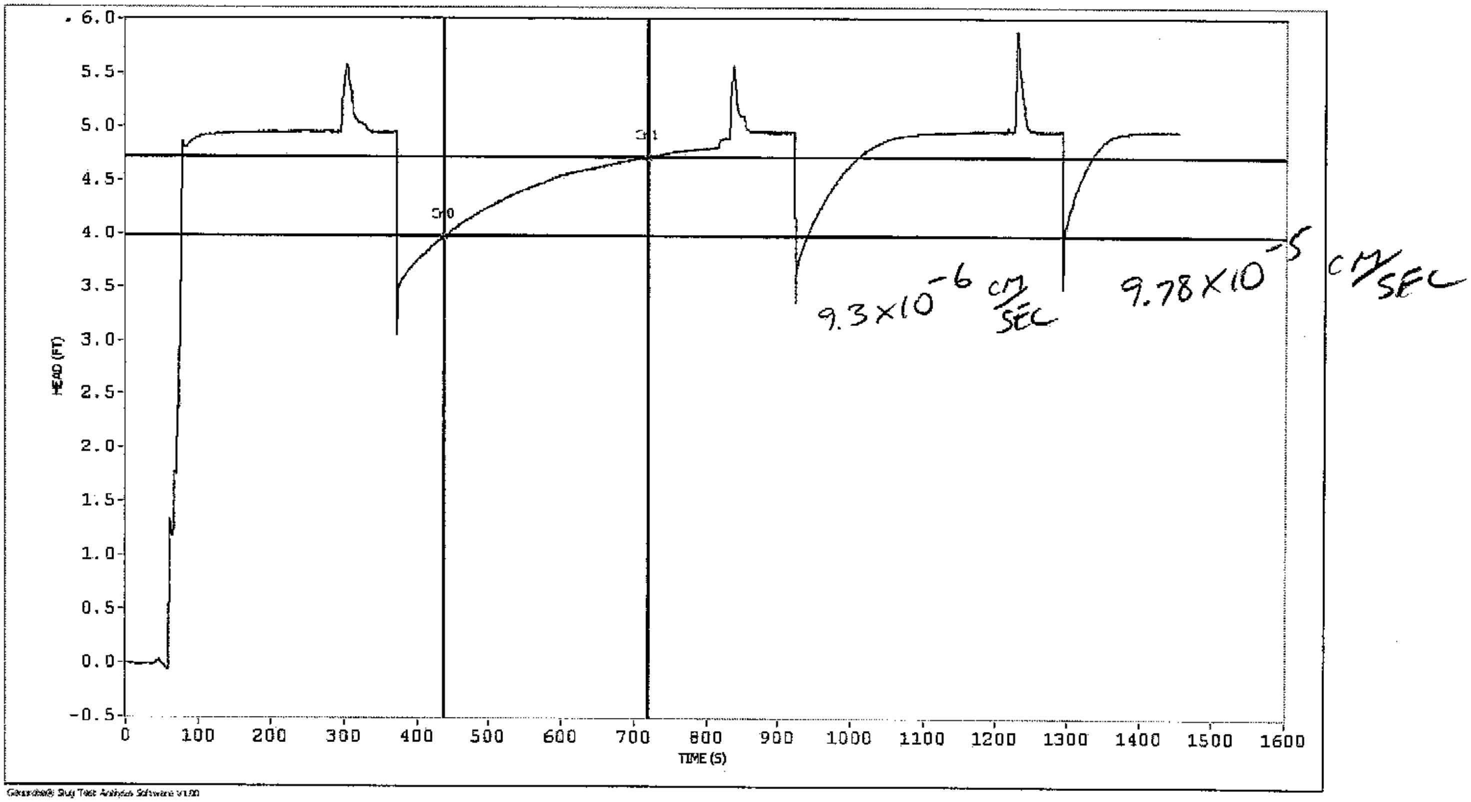
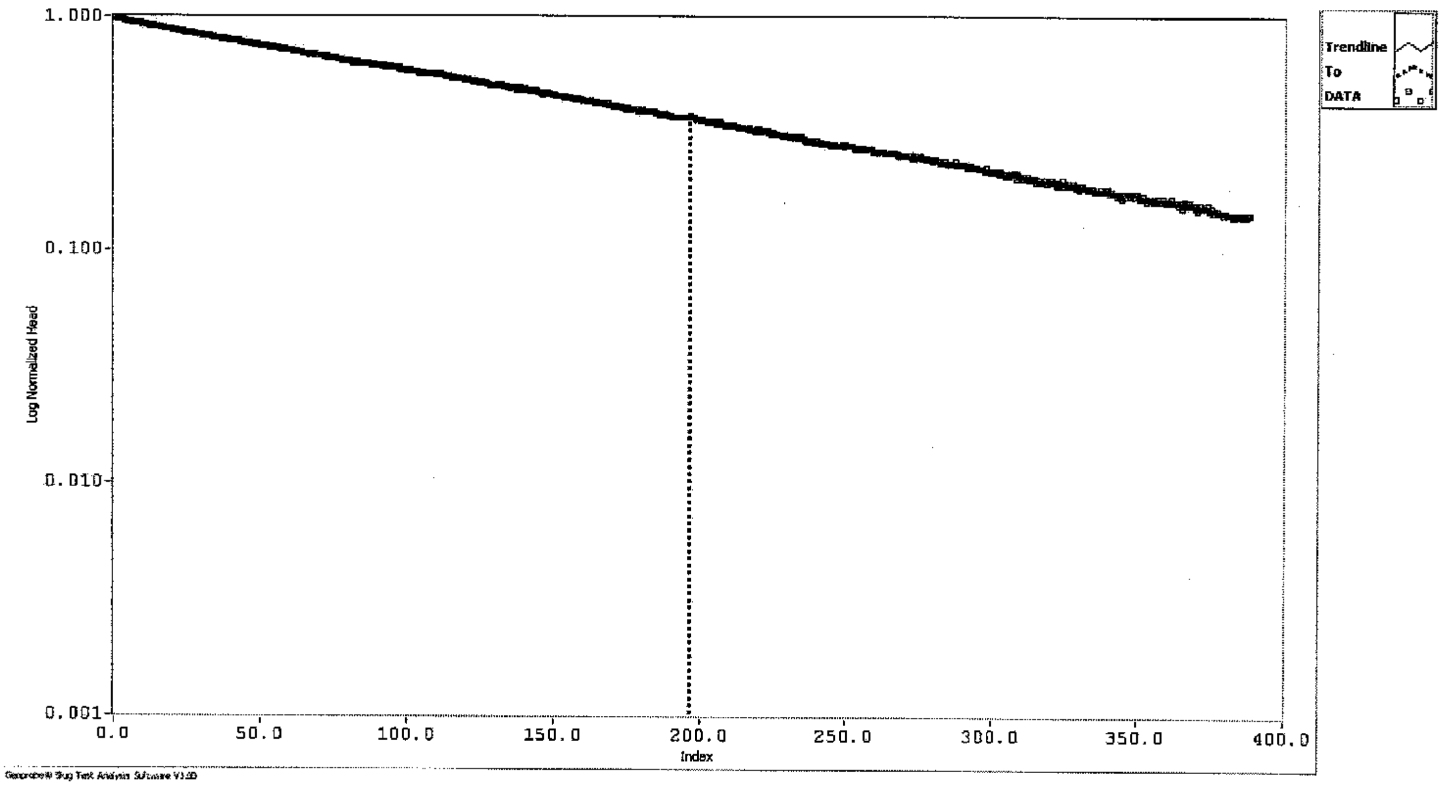
Log Data Set
File Name: C:\dirim95\ESS28-B.dat Printed: Thursday, March 02, 2006 14:04:03



ESS05 28B 14.2-15.2 FT

Interval Data Set
Interval: 923.500 Sec to 1088.000 Sec
File Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-28\ESS28 B-1 unconf .inv Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-28\ESS28-B.dat
Printed: Thursday, March 02, 2006 14:04:41



Log | Interval | INF | Parameter | Documentation/Reports

Required in Red — **Well Construction Parameters**

Le (ft)	1.000	rt (in)	0.113
Ls (ft)	1.000	SWL (ft)	4.200
Lw (ft)	6.800	TD (ft)	11.000
Rs (in)	-1.000	H (ft)	15.200
Rb (in)	0.500	Ho (in)	-1.000
Rc (in)	0.250	Well	Fully Penetrating

Site Data

Site Name:	Evap pond B
Project #:	San Luis Drain
Well #:	ES5-05-28 (B-1)
Test #:	ES527B-1 (10.0-
Location:	Butte Ave.
Date:	9/22/05
Field Tech:	J. Vauk
Analyst:	J. Vauk

Log Name
C:\dirim95\logfiles\San Luis Drain\evap B\ES5-05-28\ ES528-B.dat

Interval Name
C:\dirim95\logfiles\San Luis Drain\evap B\ES5-05-28\ ES528 B-1 unconf .inv

Start Time	End Time
923.500	1068.000

Analysis

Response	Log
Configuration	Confined
Analysis Algorithm	Hvorslev
Baseline (ft)	3.411
t*d/t*	-1.000
Cd	-1.000
K-Correction small dia wells	-1.000

Partially Penetrating Parameters

Where Le/Rb = 24.000

A = -1.000 B = -1.000

Fully Penetrating Parameter

C = -1.000

Log Response Parameters

D Coeff	-0.005
R-squared	9.99E-1
Amplitude	0.978
To	196.525

Calculated K

K (FT/Day)	0.026
K (cm/Sec)	9.335E-6
Well	Fully Penetrating

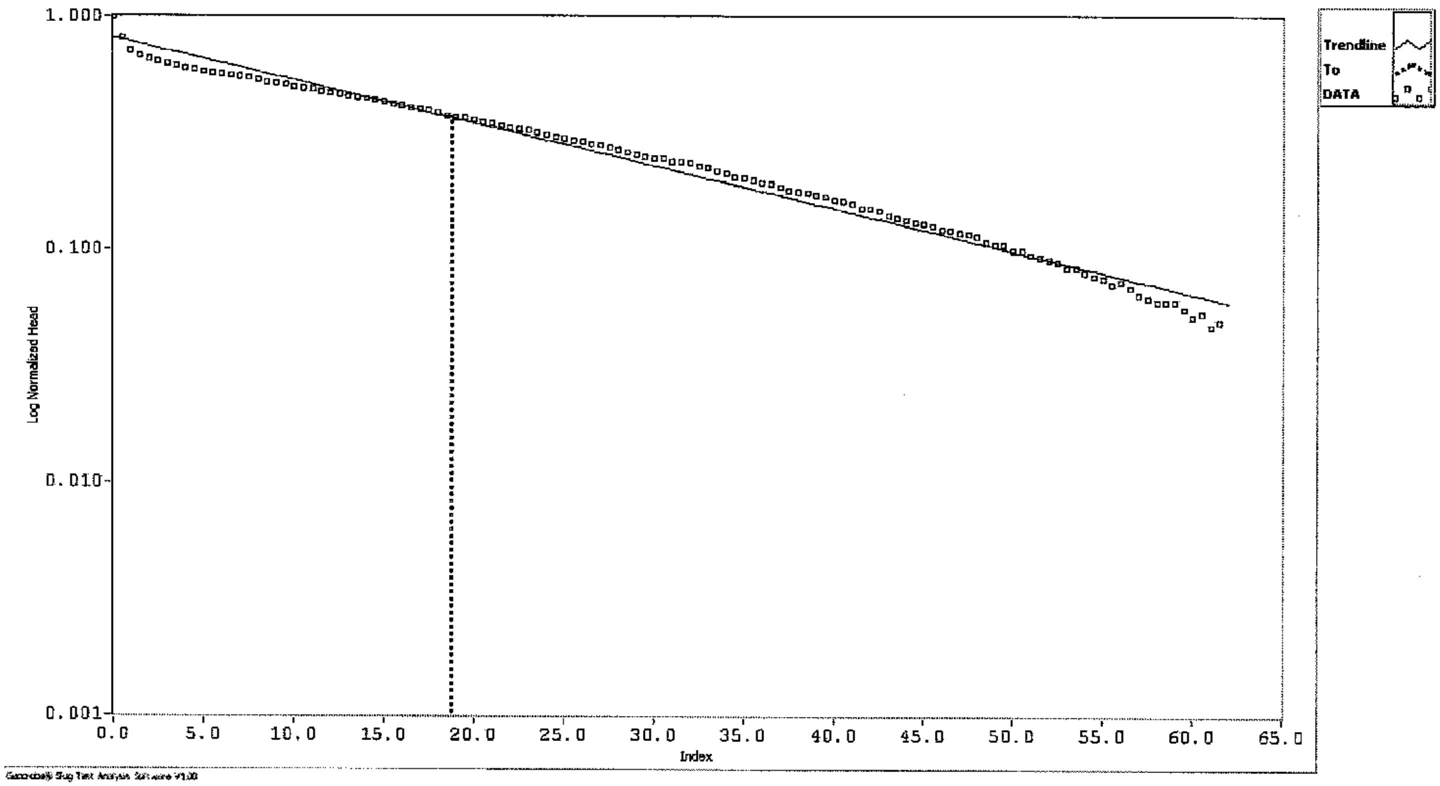
Documentation and Reports

View Parameter Graphic

View Parameter Definitions

Print This Page

Interval Data Set
Interval: 1294.000 Sec to 1452.000 Sec
File Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-28\ESS28 B-2 unconf .inv Log Name: C:\dirim95\logfiles\San Luis Drain\evap B\ESS-05-28\ESS28-B.dat
Printed: Thursday, March 02, 2006 14:05:09



Log | Interval | INF | Parameter | Documentation/Reports

Required in Red **Well Construction Parameters**

Le (ft)	1.000	rt (in)	0.113
Ls (ft)	-1.000	SWL (ft)	4.200
Lw (ft)	6.800	TD (ft)	11.000
Rs (in)	-1.000	H (ft)	15.200
Rb (in)	0.500	Ho (in)	-1.000
Rc (in)	0.250	Well	Fully Penetrating

Site Data

Site Name:	Evap Pond B
Project #:	San Luis Drain
Well #:	ES5-05-28 (B-3)
Test #:	ES528B-3 (10.0-
Location:	Butte and Cerini
Date:	9/22/05
Field Tech:	J. Vauk
Analyst:	J. Vauk

Log Name
C:\dirim95\logfiles\San Luis Drain\evap B\ES5-05-28\ ES528-B.dat

Interval Name
C:\dirim95\logfiles\San Luis Drain\evap B\ES5-05-28\ ES528 B-2 unconf .inv

Start Time	End Time
1294.000	1452.000

Analysis

Response	Log
Configuration	Confined
Analysis Algorithm	Hvorslev
Baseline (ft)	4.960
t*d/t*	-1.000
Cd	-1.000
K-Correction small dia wells	-1.000

Partially Penetrating Parameters
Where Le/Rb = 24.000
A = -1.000 B = -1.000

Fully Penetrating Parameter
C = -1.000

Log Response Parameters

D Coeff	-0.042	R-squared	9.81E-1
Amplitude	0.816	To	18.757

Calculated K

K (FT/Day)	0.277
K (cm/Sec)	9.781E-5
Well	Fully Penetrating

Documentation and Reports

View Parameter Graphic

View Parameter Definitions

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